POWER

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Analysis or Intuition?

WE DO many things by intuition or accident that would remain for a long time undone if they had to be arrived at by analytical application of the physical principles involved.

How long would it have taken man to get to walking erect if its accomplishment had involved a knowledge of keeping his center of gravity over a moving base, the laws of motion, the effects of inertia and momentum?

He just found that he could do it. The analysis and understanding of the mechanics of it came later.

Many instances of this idea occur in the history of mechanics and invention. I surmise that Gifford arrived at the injector rather by observing the entraining action of a jet than by a reasoned application of the principle of the persistence of motion of the common center of gravity.

A recent case in point is that of the Jones bearing. As the story comes to me, when J. D. Jones was master mechanic of the Washington and Columbia River Railroad a number of new locomotives came in which were subject to heating in the main bearings.

To the bewilderment of those who were dealing with the trouble, Jones drilled holes through the bottom box to the oil cell below, put the bearing together and told them to try it out.

There seemed to be no reason why, by the passage of the shaft over the tops of these holes, oil should be drawn up from a reservoir several inches below the bottom of the bearing, but it was, and the trouble with the lot of bad-acting bearings was overcome.

And now those who are wise in such things are trying to explain why the oil flows upward to the bearing through some of these holes and back to the oil cell through others; why this action occurs in a bearing started dry and against the action of the bearing pressure.

Several university and other laboratories are at work upon the problem of trying to accord the action of this bearing with the accepted principles of lubrication. Models with glass tubes have been constructed showing that the circulation occurs and how, but not what makes it.

Was it a hunch, intuition or the application of some past observation?

F. R. Low

EDITORIALS

A New Era In Boiler Construction

A NEW ERA in boiler construction was inaugurated on July 6, when the new code for the fusion welding of power boiler drums was officially approved by the Executive Committee of the A.S.M.E. Council. For more than ten years the question of fusion-welded boilers has been agitated. Each year has brought increasing pressure on the committee to issue a welding code. Throughout this agitation the code committee has maintained a conservative attitude, but one of increasing interest. Agreeing that many fabricators could produce sound welds, the committee asked how a code could insure the adequacy of welding done anywhere without specifying the process to be used.

Little progress was made until, about three years ago, the cooperation of the American Welding Society was enlisted. Since that time the A.W.S. committee has functioned continuously in cooperation with the Boiler Code Committee. The expert welding knowledge and experience thus brought to the code committee's aid plus the help given by a large number of manufacturers has made possible the present result.

Proposed welding codes were published for criticism from time to time. Then, with ample opportunity for public discussion, the code finally assumed its present form, acceptable, in the main, to most of the welding and manufacturing interests involved as well as to the code committee.

It should not be assumed, however, that the code is, in all respects, satisfactory to all fabricators. Against considerable opposition the code committee insisted on retaining rigorous X-ray and stress-relieving requirements. X-ray photographs must be made of every foot of welded seam. The completed drum must be stress relieved by over-all heating to 1,200 degrees Fahrenheit, followed by slow cooling. These requirements apply to Class 1 unfired pressure vessels as well as boiler drums.

It is easy to understand the criticism of these requirements when one considers the investment and operating expenses involved in their application. On the other hand, it appears that many users are willing to pay the additional cost as a double check on safety. Finally, the fact must be recognized that the Boiler Code Committee is at present unwilling to take the responsibility of approving fusion-welded boiler drums without these requirements. For the present at least it is a case of this or nothing.

The important consideration is that fusion-welded power-boiler drums are now an accepted fact. Several large boiler manufacturers have been getting ready for this day with years of research and technical preparation. It is to be assumed that fusion-welded boiler drums will soon be available for use anywhere in the United States, and that the rapid increase in their production will have a profound effect in the power field, particularly among the manufacturers of power equipment.

With this development in the power field will grow a similar development in the field of unfired pressure vessels. The code established the requirements for three classes of such vessels.

"Where There Is Smoke There Is Fire"

QUITE as might be expected, there are decided differences among advocates and experts as to how best to proceed in the crusade for pure air.

While all agree that some of the most prolific producers of air contamination are the users of coal in the homes, the chemical, cement, waste-reclamation and similar fume-producing industries, the industries that produce smoke and soot are the present center of interest.

There are something like one hundred fifty different smoke ordinances in the United States at present, many of which are more or less dormant, while others form the basis for militant corrective operations.

But even the latter are not in agreement as to procedure. Some authorities say the prevailing policy of permitting a degree of smoke discharge from chimneys is wrong and nothing less than complete elimination will do. Others insist that the way to abate smake is to prevent it. And they are technically correct.

Call it what you will, prevention, abatement, elimination or eradication—after all, "What's in a name? That which we call a rose, by any other name would smell as sweet"—none of these differences is sufficient to

obscure the main issue. Rather they accentuate it, for they serve to show the mental activity concentrating on the problem. Where there is so much smoke there is certain to be fire.

All of which leads to the conclusion that there are good business opportunities ahead for competent smoke ordinance administrators, men who by temperament and engineering training are adapted to undertake the enforcement of smoke laws diplomatically, firmly and with sympathetic understanding for the problems of offenders, most of whom need only education and assistance for their conversion.

These administrators will need many smoke inspectors to take charge of the firing line. It will be well worth while for qualified ambitious operating men to investigate these possibilities in their home districts or elsewhere.

Turbine-Electric Drive Not Discredited

ASTONISHMENT was caused when the Navy Department announced last week that in reconditioning the battleship New Mexico the turbine-electric drive is to be replaced by turbines and reduction gears. This ship, commissioned at the end of the war, was the first battleship to have turbine-electric drive, and attracted widespread attention at the time. It was largely as a result of her excellent performance, and that of the collier Jupiter, similarly equipped, that subsequent battleships were fitted with electric drive. The post-war cruisers have geared turbines largely because of the saving in weight which permits full advantage to be taken of all tonnage allowances under the Washington treaty.

The introduction of turbine-electric drive on naval vessels was brought about only after several years of strong opposition on the part of certain naval officers and shipbuilders. An account of this is contained in the recently published autobiography of W. L. R. Emmet, to whom major credit for the accomplishment is due.

Lest the recent decision as to the New Mexico be interpreted as an indictment of electric drive, it is well to point out that the subsequent statement of the Navy Department reaffirmed its confidence in this form of propulsion and justified its course solely on the grounds of a saving of three hundred thousand dollars. This is in line with the Government's announced economy program. Furthermore, the bulkhead arrangement of the New Mexico was originally laid out for geared turbines, and their installation will involve no structural alterations.

Although the statement of the Navy Department makes no reference to the saving in weight, it is possible that this may have been a further consideration.

It is reassuring to know that the electric drive has not fallen into disfavor.

Binary-Vapor Cycles

THE SUCCESS of the combined mercury vapor-steam cycle at Hartford, Conn., and the decision to install two larger units elsewhere have prompted numerous questions as to binary-vapor cycles in general. When it is stated that binary vapors are employed in order to utilize heat at higher initial temperatures, confusion sometimes arises in the minds of those who have come to understand that, because of metal limitations, design temperatures for steam have not exceeded 825 to 850 deg., except in experimental installations.

For those whose knowledge of the subject is elementary, it should be pointed out that the boiling points of most binary fluids are much higher than steam for the same gage pressure. Mercury, for instance, at 70 lb. gage pressure boils at 884 deg. F., while the boiling point of steam at this pressure is only 316 deg. F. In these days of high efficiency no one would think of using steam at only 70 lb. even if it were superheated to 884 deg. F. The use of high pressures with steam involves the employment of high temperatures with higher resultant stresses on boilers, piping and other parts. The lower pressure of the mercury imposes less severe service on steel parts and is therefore more adaptable to high temperatures.

The main consideration is the heat content of the working fluid. More heat is available as latent heat for work in the mercury-steam cycle than in the steam cycle alone at the same final temperature even though the steam be superheated.

Certain modified binary-vapor cycles are under consideration where the high-temperature fluid is used merely as a heat carrier from the furnace to the steam where it can provide initially high superheat or can be used in place of high-pressure steam, or of furnace gases for reheaters. The heating fluid can be under a very moderate pressure even at the high temperature.

While binary-vapor cycles lead to higher thermal efficiency, the extent of their use will depend to a large extent on the first costs of equipment. These costs have not been fully established. But they are being studied and each new installation will offer additional data that will help to establish the economic place of binary-vapor cycles in power generation.

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POWER Stands for . .

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**
8. **Prevention of Smoke, Within Reason**

HOW PULVERIZED COAL BURNS AS SHOWN BY THE

By DOUGLAS HENDERSON
Vice-President Fuel Engineering Company of New York

IT HAS BEEN outlined in a previous article[1] that the combustion of bituminous coal is a two-stage process. First the gaseous content is distilled off and diffuses with the oxygen supplied by the incoming air, resulting in the combustion of these gases. Secondly, the residue of solid carbon to be burned must be kept in the furnace at high temperature and brought into contact with a supply of oxygen.

It is becoming increasingly apparent that the real problem in the burning of coal is the combustion of the solid carbon. This has recently been the subject of considerable research, for it is realized that only from a thorough understanding of just what takes place during combustion of solid carbon in the coal can improvements in method and design be expected.

The extending use of pulverized coal has added impetus to these studies, and several valuable contributions on this subject have appeared recently.[2] Preliminary results of studies we have made lead to certain rather definite conclusions which in some important respects have not been covered by other investigators.

Solid Residue Forms Hollow Spheres of Carbon

Among other things it appears that the solid residue resulting from the combustion of coal in pulverized form is a distinct type of carbon possessing characteristics quite unlike any other form of carbon with which we are familiar. Some of these characteristics are favorable to its combustion while others actually serve as a handicap.

Instead of a dense structure, the carbon forms a hollow shell, in general being spheroidal in shape. Figs. 1, 2 and 3 show how these particles appear under the microscope. Their hollow shell-like formation can be readily identified even to the smallest size. It is from this peculiar form they derive their name, "cenosphere," meaning "empty sphere."

Cenospheres Formed From Coal Burned in Suspension

From extensive investigations it became evident that cenospheres of carbon are formed only when coal is burned in suspension. This fact was related to a known phenomenon occurring when coal undergoes heating. At some point before the volatile matter begins to distill off, coal reaches what is termed its agglutinating point, at which temperature there is a softening of the solid material. This pasty condition is followed by a hardening of the mass.

While it is, of course, a matter for conjecture as to

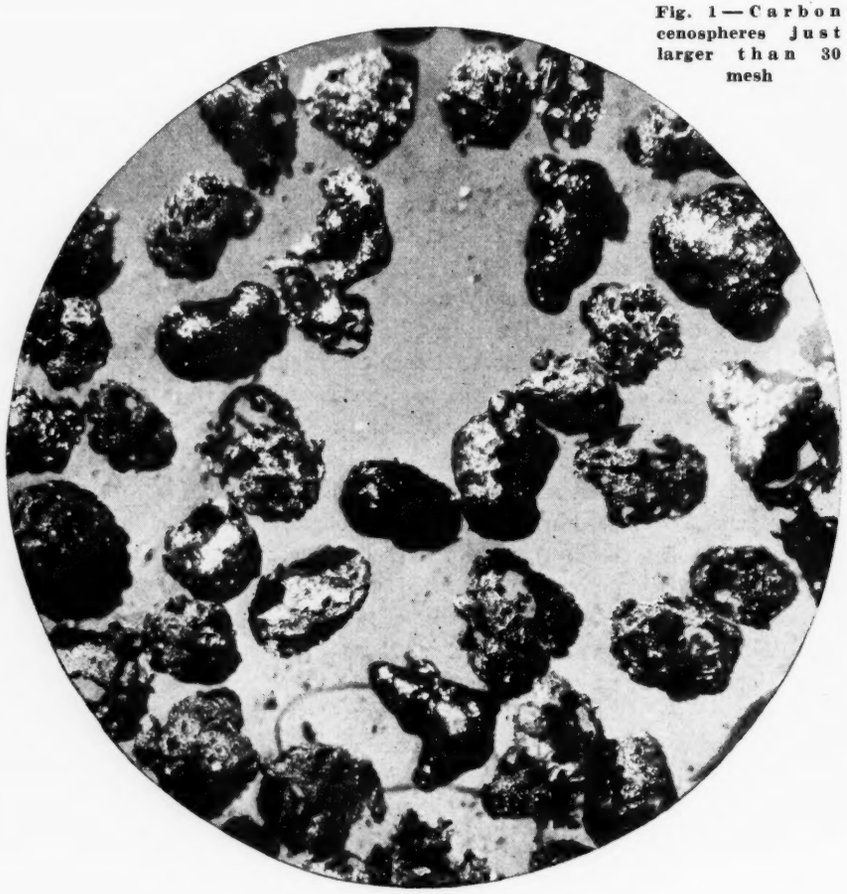

Fig. 1—Carbon cenospheres just larger than 30 mesh

[1]Douglas Henderson, "Diffusion as a Factor in Burning Pulverized Coal." POWER, Vol. 73, p. 288.

[2]S. P. Burke & T. E. W. Schumann—"The Mechanism of Combustion of Pulverized Coal." Also, David F. Smith and Austin Gudmundsen, "Mechanism of Combustion of Individual Particles of Solid Fuels." Both in *Industrial and Engineering Chemistry.*

MICROSCOPE

Microscopic studies of pulverized coal particles that have passed unconsumed through furnaces show clearly that they are hollow spheres (cenospheres) of carbon whose bouyancy increases with size. Furnace design must be based on the properties of cenospheres rather than those of solid coal or coke particles

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just how these carbon cenospheres are formed, we are inclined to believe their formation starts with the reaching of the agglutinating point. The coal particle, upon entering a hot furnace, absorbs heat rapidly by radiation, which heat brings the surface of the particles to the agglutinating point and later drives off the volatile gases from the same area. Coal being a poor conductor of heat, the surface of the particle becomes a softened stratum before the gases have been driven out.

Internal Gas Pressure Apparently Produces the Cenospheres

Pressure is developed on the interior due to the pent-up gases that have been trapped there while the surface of the particle was being sintered together. Continued heat-

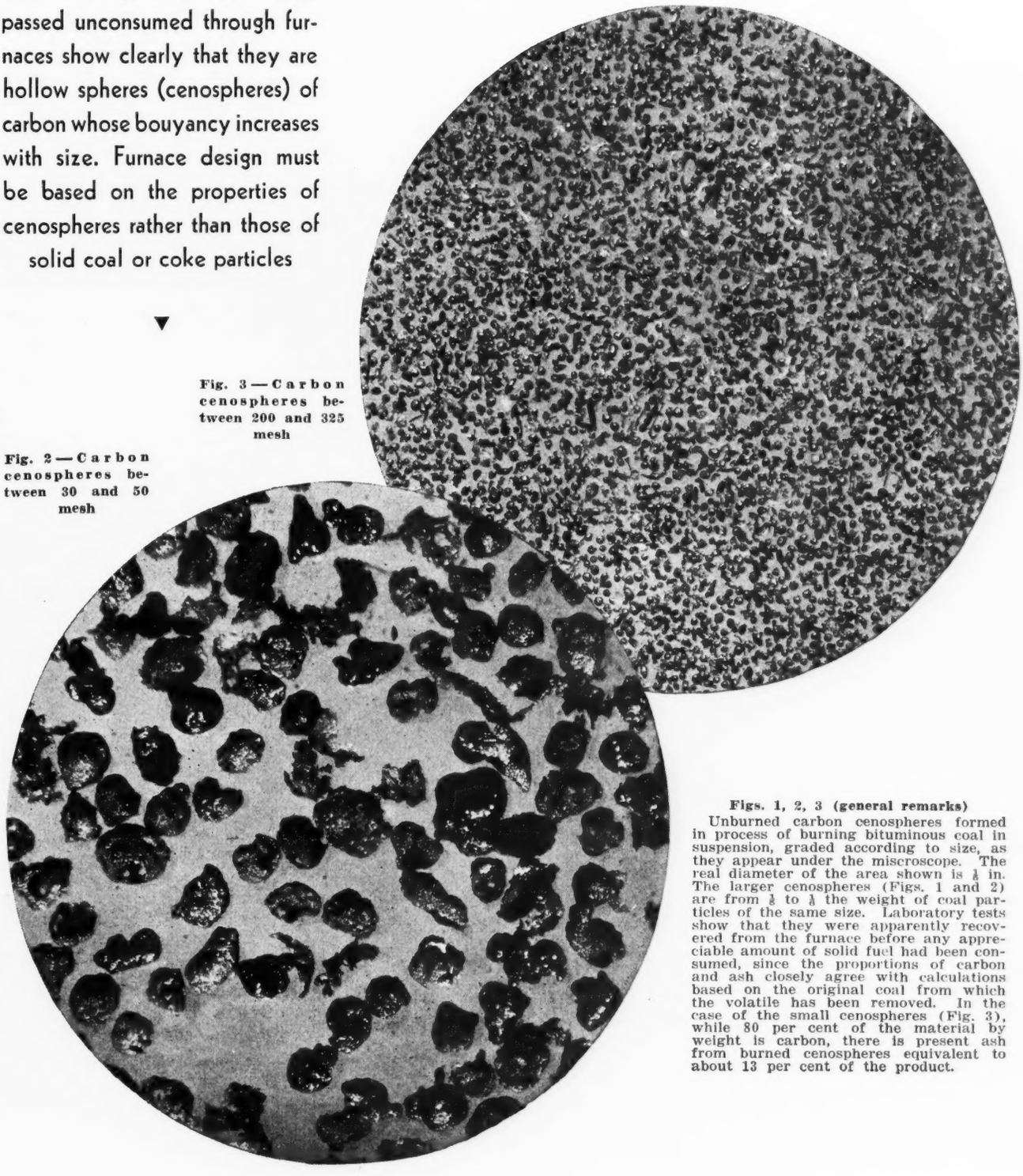


Fig. 3 — Carbon cenospheres between 200 and 325 mesh

Fig. 2 — Carbon cenospheres between 30 and 50 mesh

Figs. 1, 2, 3 (general remarks)
Unburned carbon cenospheres formed in process of burning bituminous coal in suspension, graded according to size, as they appear under the miscroscope. The real diameter of the area shown is $\frac{1}{4}$ in. The larger cenospheres (Figs. 1 and 2) are from $\frac{1}{2}$ to $\frac{1}{3}$ the weight of coal particles of the same size. Laboratory tests show that they were apparently recovered from the furnace before any appreciable amount of solid fuel had been consumed, since the proportions of carbon and ash closely agree with calculations based on the original coal from which the volatile has been removed. In the case of the small cenospheres (Fig. 3), while 80 per cent of the material by weight is carbon, there is present ash from burned cenospheres equivalent to about 13 per cent of the product.

Fig. 4—Microphotograph of particles of ordinary coke of slightly larger size than the cenospheres in Fig. 1

The area covered has a diameter of $\frac{1}{8}$ in. It can be readily seen that these particles are not only jagged, but appear much more dense in structure. Laboratory tests show that, except for the particles larger than 50 mesh, these small pieces of coke dust are heavier than coal particles of the same size. These dense, irregular-shaped coke particles are characteristic of those recovered from stoker or hand-fired plants.

ing causes the gases from the inner core to expand against the fused, and to-a-certain-extent plastic, exterior surface, thus expanding the solid matter and forming a hollow sphere. The pressure of this trapped gas continues to rise as the temperature increases, and finally the volatile gases burst through the outer crust and escape. This gas is diffused with oxygen and burned, producing a tiny comet within the furnace. The microphotographs clearly show these vent holes in the surface of the cenospheres.

This represents one theory regarding the formation of these bodies, and it may or may not be true. We do know, however, that a form of carbon is created totally unlike the coal originally fed to the furnace, and also dissimilar to the solid residue found when coal is burned on grates, either hand- or stoker-fired. Fig. 4 shows a microphotograph of coke produced on grates. This form of carbon is quite dense, and we have found that it varies in weight from 0.8 to 1.7 times the weight of a similar-sized particles of coal.

TABLE OF RELATIVE DENSITIES

Screen Size	Carbon Cenospheres	Coke	Flue Dust
Over 30	0.212	1.105	.....
Over 50	0.275	1.241	0.648
Over 100	0.435	1.425	0.920
Over 200	0.668	1.761	1.135
Over 325	0.844	2.079	1.231
Through 325	1.235	2.260	1.770

In addition to the difference in physical appearance, which is to be seen by comparing the micrographs, we have found a most interesting variation in density between the carbon cenospheres and coal particles, which have a relative density of about 1.35. Peculiarly enough, there is a further variation in density between the different sizes of cenospheres. The table presents our determinations of relative densities for carbon cenospheres formed by 26 per cent volatile coal, coke, and flue dust, with a gradation of sizes according to standard sieve meshes.

Larger Cenospheres Are More Buoyant

This indicates that the walls of the smaller cenospheres are relatively thicker than those of the larger ones. It further shows that the larger cenospheres are more buoyant, and consequently the ones that offer the least resistance to removal from the furnace by means of an air current. With their thin walls, however, they are much more reactive with oxygen and have that advantage which favors their complete combustion.

The relative density of coal is about 1.35, so that the cenospheres screened through a 325-mesh sieve approximate coal in weight. The cenospheres passing through 200 mesh have 62.5 per cent of the weight of the original coal of the same size. A particle of coal, sized to pass 200-mesh sieve, which is pulverized coal practice, will form a carbon cenosphere of approximately the same diameter. It will be, however, five-eighths of the weight of the coal particle, and for this reason difficult to retain in the furnace, especially if the air current has been proportioned to carry along the coal.

Coke Densities Give Erroneous Results

It is important that these densities be considered in any mathematical treatment of the burning of solid carbon in suspension, for the use of the densities of either coal or coke will give erroneous results. The velocities of air currents capable of supporting coal powder have been investigated at length by M. E. Audibert[3] and

[3]M. E. Audibert—"Study of the Entrainment of Coal Dust by an Air Current," Ann. Mines, 12th Ser., Vol. 1, 1922, p. 153.

others, but in every case the density used has been that of either coal or coke. In this connection it is interesting to note the variation in relative density of coke particles as presented in the foregoing tabulation.

It is a very important fact, therefore, that the density of the solid carbon produced by burning bituminous coal in suspension is much less than the density of coke formed when coal is burned on grates, because the former is much more buoyant and lends itself to suspended combustion. If this were not the case the heavier coke would tend to fall to the floor of the furnace and burn at that point in an inefficient manner.

Buoyancy Versus Reactivity

The data thus far presented show that the carbon cenospheres are light in weight and buoyant, which would indicate difficulty in causing them to remain in the furnace until consumed. Fortunately, however, these cenospheres possess a property most valuable for their combustion. It is their avidity for oxygen, or their "reactivity." Carbon cenospheres of any size from 30 mesh down when introduced into a furnace with a temperature as low as 1,650 deg. F. instantly react with oxygen in the air, and the entire mass will glow. The same experiment carried out with coal or coke particles of the same size requires appreciably longer to reach the same glow point.

Study Combustion by End Conditions

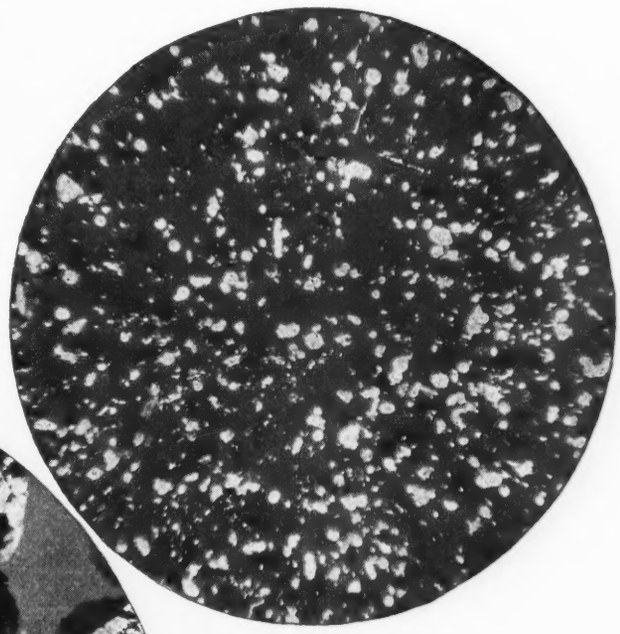
Thus we have two factors, one unfavorable and the other favorable, in the combustion of these exploded particles of solid carbon. Both factors must be considered in furnace design so that they may be balanced and the carbon be burned completely before emission from the furnace.

It is most difficult to examine the process of combustion in a hot furnace, the heat and brilliance of the phenomenon setting up an impenetrable barrier. We can gain much information from the two end conditions; that is, the coal before and the resultant material after passing through the furnace. After much research conducted on the material removed from pulverized-coal furnaces we have obtained confirmation as to the buoyancy of the cenospheres. The stack emission from plants burning pulverized coal is a combination of the ash in the coal and carbon cenospheres.

Find Cenospheres in Flue Dust

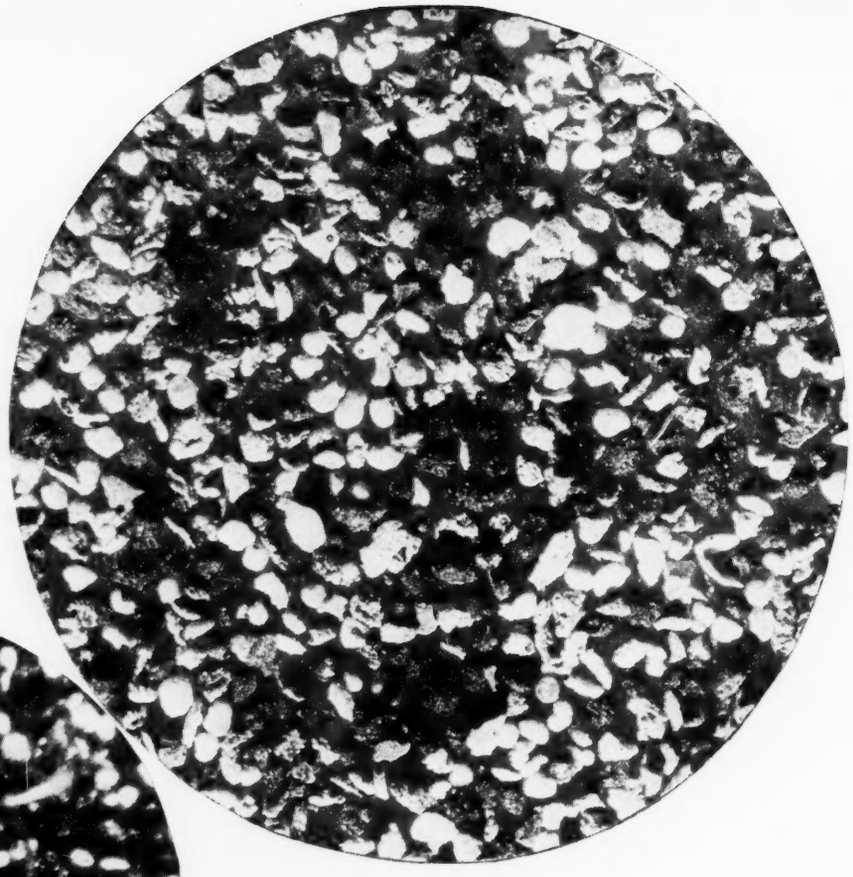
Figs. 5 and 6 show microphotographs of flue dust, as the stack emission is commonly called, collected from a pulverized-coal-burning plant. The spherical form is clearly seen in both the material screened over 30 mesh and that through 325 mesh. Even the ash has assumed globular shape. The figures we have obtained for the relative density of this material are shown in the table.

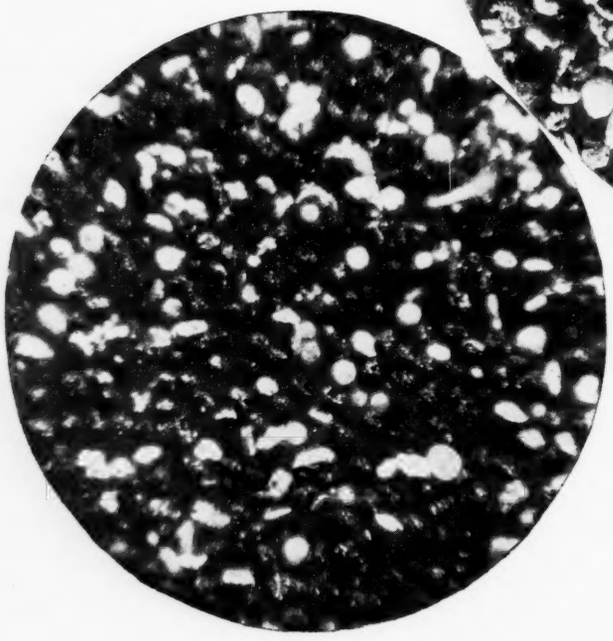
The flue dust is decidedly heavier than the carbon cenospheres because of the preponderance of ash. The



Figs. 5 and 6—Microphotographs of flue dust from pulverized coal unit, separated by screening, the larger particles (Fig. 5, left) being 30 mesh size, and the smaller ones (Fig. 6, above) through a 325-mesh screen

The actual area covered by Fig. 6 is about $\frac{1}{16}$ of an inch and of Fig. 5, $\frac{1}{8}$ in. While the material sized over a 30-mesh screen (Fig. 5) has only a small proportion of additional ash from burned cenospheres, the smaller material (Fig. 6) contains less than 6 per cent of combustible. An unknown but probably a substantial amount of small carbon cenospheres, more bouyant than the ash, was carried out the stack in this case.





Figs. 7 and 8—Microphotographs of flue dust recovered by electrical precipitation, separated by screening

The material shown in Fig. 7 (right) is between 50 and 100 mesh, while that in Fig. 8 (below) is between 200 and 325 mesh. The material through 325 mesh recovered by electrical precipitation in this plant contained relatively 3 times as much unburned carbon as the material (shown in Fig. 6) taken from another plant in which the passage of the lighter carbon cenospheres out the stack was not interrupted by any dust-recovery method. The actual diameter of the area photographed in Fig. 8 is 0.06 in., while the diameter of the area in Fig. 7 is 0.20 in.

gross sample of the flue dust that was taken to prepare Fig. 5 contained 69.2 per cent unburned carbon, while the sample of that passing through a 325-mesh screen, Fig. 6, contained 5.8 per cent combustible matter. It so happens that the above specimens of flue dust were collected at a plant not equipped with dust-recovery apparatus, and that considerable emission took place from the stack. The samples shown in the photographs were collected from accumulations in the boiler passes, breeching, etc. It represented what had settled out of the products of combustion on their passage from furnace to stack. Considering that the small cenospheres are lighter than the ash, it is quite logical to assume that the material that issued from the stack in this case was largely carbon.

Larger Cenospheres Consumed in Furnace

This conclusion is verified to a certain extent by Figs. 7 and 8, which are microphotographs of flue dust thrown down by electrical precipitation. The material screened through 50 and over 100 mesh contained 8.5 per cent combustible, while that screened through 200 mesh contained 10.2 per cent unburned carbon. Seventy-six per cent of the material thrown down by the precipitators passed through a 325-mesh sieve, and it contained 15.9 per cent combustible matter. From this it appears that under conditions of no precipitation the natural velocities through the boiler and stack are favorable to the entrainment of carbon cenospheres of small size. The larger ones are undoubtedly consumed before leaving the furnace.

The entrainment of carbon cenospheres from pulverized coal furnaces is further disclosed by the magnitude of the "unaccounted-for" losses recorded when complete heat-balance figures have been compiled from tests conducted on boilers equipped with such furnaces. We have found these losses to exceed the proportions obtained in the case of stoker-fired boilers. As a matter of fact, this unaccounted-for loss may be the largest single loss item in the heat balance of a pulverized-coal-fired unit, particularly if the boilers are equipped with auxiliary heat recovery apparatus, such as economizers, air-preheaters and water walls. All of these devices serve to apply the sensible heat in the stack gases and the furnace to useful purposes. The entrainment of carbon cenospheres from the furnace represents a failure to release their heat, and hence the development of an unaccounted-for loss.

To bring this item into line requires the application of the known facts about the elusive carbon cenospheres so that they may be retained in the furnace until burned. This can only be accomplished by proportioning air flow through the furnace with a proper regard to the relative densities of the cenospheres. It may mean modifying furnace design, burner design and location. Possibly the observations presented here will aid in arriving at the ideal combination.

CORROSION PREVENTION by Metal Composition

Efforts have been made to increase the resistance of metals to corrosion along two principal lines. The first has been to establish alloy ferrous metals whose composition involves the introduction of elements which, when combined with iron, offer greater resistance to corrosion than iron in its usual commercial condition. The second has been to inhibit corrosion by means of protective coatings of various compositions. The first method has met with a certain degree of success and is the subject of this article, while the latter means will be discussed in the concluding article of this series[1]

By W. S. JOHNSTON

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WHILE the earliest investigations of corrosion, dating back nearly a century ago, covered its effects under the different conditions then usually obtaining, we are particularly interested in those involving corrosion of cast and wrought irons and steel by fresh water. The reported results from many sources differ considerably, probably due to a lack of uniformity of conditions under which the corrosion occurred. It is reasonable to conclude from them that steel, as then made, offered the least resistance to corrosive action while wrought iron and cast iron, in the order named, did not succumb so readily. It is doubtlessly due to the evidence secured during these investigations that the popularity of wrought iron had its inception. Certainly there are many instances of buried wrought-iron pipe in water-works service which has withstood for long periods corrosive attack from inside and out without complete disintegration.

Later investigations have been conducted with greater regard to the controlling factors and the conclusions drawn are probably more accurate. W. C. Richardson's laboratory tests reported in 1920 show that, of five commercial iron and steel pieces totally submerged in unagitated distilled water, open-hearth steel experienced the least loss of weight. Copper-bearing steel, however, withstood corrosion quite as well as open-hearth. The results differed when the water, in which the test pieces were immersed, was agitated with air. Gray cast iron showed the least effect while wrought iron and open-hearth and Bessemer steels were most affected. Open-hearth pure iron and copper-bearing steel occupied positions about midway of the two extremes. It is worthy of note that the composition of the samples was not the controlling factor in determining corrosion resistance under the test conditions, and that the latter simulated those found in the pipes, tanks, and other water containers in power plant use as the samples were totally submerged. Furthermore, the experiments were not for a short period of time, but covered nearly three years at ordinary room temperatures of 70 to 90 degrees.

A few years after the Richardson report was published, J. N. Friend made public the results of his experiments wherein test pieces were submerged in a tank of Birmingham, England, city water, at normal temperatures, which was filled and emptied every couple of hours for a period of a year. Ingot and wrought irons and medium and mild steels did not appreciably differ in their resistance to corrosion. A 12-point carbon steel with 36.6 per cent nickel and a 36-point stainless steel with 13.6 per cent chromium were hardly affected, though comparatively the latter stood up nearly three times as well as the former.

Further laboratory tests covering a year with the same water in which the samples were continuously submerged continued to show stainless steel as being most resistant to corrosion among a group of samples of nickel-chromium steels, copper-bearing and carbon steels, as well as cast and wrought irons. The nickel alloys were more resistant as the nickel content was increased. Copper bearing steel offered greater resistance than did the carbon steel.

It is difficult to find data that supports in all cases the prevailing impression of the superiority of wrought iron to steel in withstanding corrosive attack. A compilation of all known data some years ago indicated there was little choice between the two insofar as corrodibility in either fresh or salt water was concerned. The proponents of either may point to certain instances where well established facts would seem to confirm their choice. However, in the case of corrosion under water, whether it be hot or cold, such as obtains in power plant service,

[1]The first article discussing the causes and various forms of corrosion under title, "Corrosion—What It Is," appeared in the July 21 number.

laboratory results and field observations are in substantial accord that the commercial grades of either offer no marked advantages over the other. Wrought iron may afford greater corrosive resistance than steel when placed underground.

The desirability of using iron versus steel boiler tubes has been investigated frequently and the subject is still discussed, but it is significant that less than 10 per cent of all the boiler tubes made are of iron. A survey of gas companies conducted a few years ago developed the fact that more than a majority of them use steel for service pipes. Any statement concerning the relative merits of wrought iron and steel, in cases of corrosion, should be qualified to identify the nature of the corrosion for, probably, each has properties that makes its use desirable under certain conditions.

Outer Skin Affords Protection to Cast Iron

It is well known that cast iron is more corrosive resisting than steel. However, if the outer surface is removed and the bare metal exposed under the same conditions as a piece of steel, both will corrode in water at the same rate. Hence, it is evident that the outer skin developed in the sand mold affords protection against corrosion to the heart of the metal. This is another instance where a factor other than composition controls the corrodibility. Probably the corrosion of the outer skin gives further protection, as the rust adheres to the rough surface. If the cast iron is submerged, the rust structure is porous and of little value as a protective coating.

The rate of corrosion of ferrous metals under certain conditions is sometimes determined by the composition of the metal and the uniformity of its structure. Slag inclusions have been thought of as affording protection to the particles of iron but, upon an examination of their distribution, it has been found they are very irregular and the iron is almost wholly open to attack. While slag may offer some mechanical interference yet, being a cathode with respect to the adjacent iron, it will actually aid corrosion by affording places for hydrogen deposits. Nonmetallic foreign materials in the structure of ferrous metals generally act in a similar manner. This is one of the reasons that the rustless or stainless steels must be as free as possible of such material.

Mill scale is formed on the surface by exposure to air at elevated temperatures. Its presence leads to intensified local corrosion at the junction of the scale and iron, which is explained by the fact that it acts in a cathodic manner just as slag. Scale may be removed by sand blasting, acid pickling or by a hot process in the finishing operation.

External Factors Outweigh Composition

The metal iron in ferrous structures occurs as crystals of iron. The crystals are of various, irregular sizes, but as yet there has not been any definite relation established between their ordinary variations and corrosion resistance. A careful study of the evidence available to date indicates that the composition of commercial iron and steel is less of a controlling factor in corrosion than the service conditions to which they are subjected. The influence of external factors probably outweighs that of internal factors.

An exception to the foregoing statement is the case of alloy ferrous metals whose constituents are especially selected to withstand corrosive attack. Composition affects the solution pressure of the predominating metal and the constituents may be factors in corrosion by their tendency to form a protective film and influence the hydrogen concentration upon the surface. The subject of alloys, even when confined to the ferrous group, is a large one. The number of combinations is myriad as the quantity of one constituent is held constant while all the others vary over a wide range. Only the general effect of metals used in combination with iron to resist corrosion will be discussed briefly.

Phosphorous, sulphur, and manganese are usually present in some quantity in all ferrous metals. In general, they exert but little influence on corrosion, though experiments indicate that the amounts of each in conjunction with the others may be minor factors, under certain conditions of atmosphere, immersion and acidity. Silicon, on the other hand, if present in excess of a certain minimum quantity, assists in resisting corrosion. Commercially it occurs as iron silicide crystals and is the basis of a number of alloys of which duriron is typical. A number of other elements have been alloyed with iron for reasons of structural characteristics or physical properties, such as molybdenum, tungsten, vanadium, etc., but the knowledge of their effect on corrosion is meager.

Nickel and Chromium Alloys

There are other alloys also, which offer very definite corrosion resisting characteristics in combination with iron. They are the basis of the rustless iron and stainless steel groups of ferrous metals. Nickel and chromium are the best known and most widely used, either separately or together. Less than 3 per cent nickel is apparently of no assistance, but increasing it up to a maximum of over 25 per cent decreases the tendency to corrode.

Chromium alloys are of two kinds, known as stainless iron and stainless steel. The former contains less than 0.10 per cent carbon and 10–15 per cent chromium. Its surface, as it comes from the finishing rolls, has a very low rate of corrosion and is extensively used where subject to atmospheric corrosion, as well as in power plant equipment for trimming steam valves and certain turbine parts. Stainless steel has 0.20-0.40 per cent carbon and about 13 per cent chromium. It may be heat-treated and polished for cutlery purposes, but the surface finish is of great importance. The popular idea that these stainless steels will not rust is erroneous. They possess considerable resistance to ordinary corrosion and that due to weak vegetable acids, but succumb to strong acids and atmospheric corrosion over a long period of time.

Alloys with nickel and chromium offer exceptional resistance to corrosion in industrial service. Neither elevated temperatures oxidize them nor do the usual atmospheric and water conditions attack them. While expensive, their cost is not prohibitive and their use is being rapidly extended. They represent the best efforts to combat corrosion by composition.

Surface Effects

In an effort to minimize the tendency to corrode, especially pitting of the metal, a process was developed some years ago known as "Spellerizing." The bloom in the steel mill is alternately passed back and forth between rolls with sharp projections arranged in regular pattern and smooth rolls. The mill thus endeavors to produce a uniformly dense surface on the finished product. The process does not alter the composition of the metal, but has been successful as one means of offering resistance

to corrosive action. It is mentioned here as another illustration of the recognized principle that the place to combat corrosion is at the surface.

The proponents of rustless or stainless iron and steel cannot take exception to the principle just mentioned for in the last analysis these alloy metals resist corrosion only through the stability of their surfaces. Probably the explanation lies in the fact that the alloy affords a protective film over the iron. A solid solution more resistant than commercial iron has been formed that does not corrode either easily or quickly under ordinary conditions. The results of experiments show, though, that pickled stainless iron has greater resistance than the polished metal under certain conditions.

There are available for power plant structures and equipment both iron and steel that are practically non-corrosive because of their composition. Copper-bearing steel is used generally in plate work where damp conditions obtain or the metal is continually or intermittently wet due to water flowing over it. Very rarely, though, is it used for tankage. The stainless ferrous metals have found a place of considerable usefulness in valve trim, turbine parts, and wherever their combined chemical and physical properties make their use ideal to withstand corrosion, erosion and stresses developed by external strains. However, because of the relatively high cost per pound of alloy metals, they are not used generally for bulky parts of plant equipment as boiler drum sheets and boiler, economizer and furnace water wall tubes. Some alloy tubes have been used in the construction of superheaters for 1,000 deg. F. steam because of the higher tensile strength of nickel chrome steels at this temperature.

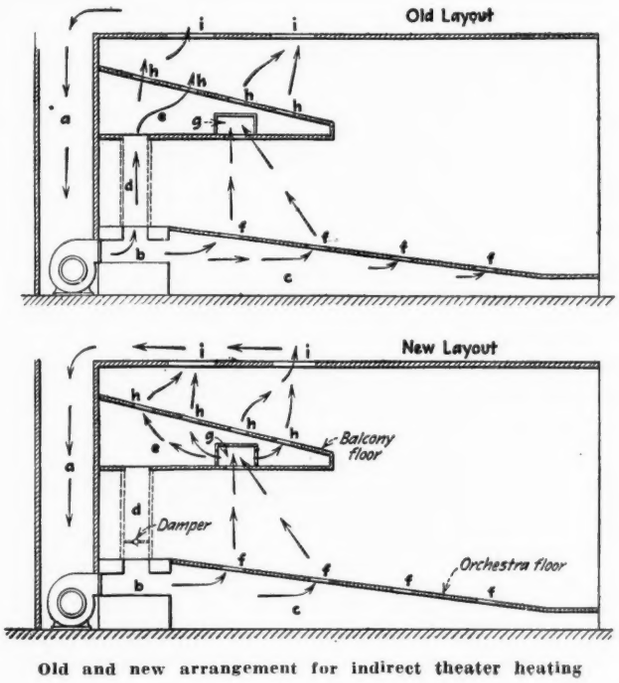
However wide the use of corrosive resisting metals may be there remains a large tonnage of commercial iron and steel that is susceptible to attack. It must be protected against disintegration by applying to its surface a film at once impenetrable and stable over a wide range of temperature conditions. It has been conservatively estimated that fifteen to twenty million tons of iron and steel are annually lost in the United States by rust wastage. Probably the greater part is due to atmospheric corrosion. The portion attributable to the power plants of the country largely occurs under water and its extent is unknown until failure is about to occur or has already transpired and replacement is necessary.

▼ ▼ ▼

Changes in Theater Heating Save Fuel and Power

By A. F. SHEEHAN
Springfield, Mass.

IN THE HEATING SEASON just ended an experiment made in indirect heating resulted in substantial savings. One of the buildings heated by our boiler plant is a 2,500-seat theater. Complaints had been received that the main floor was colder than the balcony. Only enough direct radiation was installed to give an inside temperature of 62 deg. in zero weather, and at 12 o'clock each day the indirect coils were used to raise the temperature to 72 degrees.



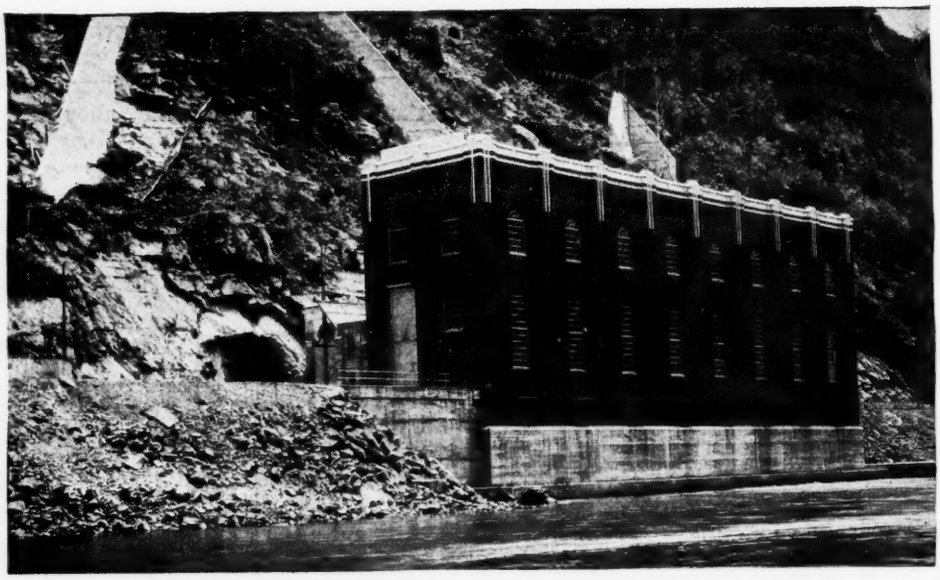
Old and new arrangement for indirect theater heating

As shown in the sketch, the air supply coming from the roof level through airshaft *a* is forced by fan *b* through coils into air chambers *c* and *e*, which supply the main floor and balcony, respectively. Half the air went through openings *f* to the main floor and exhausted through horizontal flue *g* to the atmosphere. The remainder went through flue *d* to the balcony air chamber *e* and through the openings *h* to the balcony and exhausted through roof vents *i*.

As the theater was unoccupied during the warming-up period, except for the operating staff, it was decided to cut the amount of air used in half and deliver it at a higher temperature. At first the fan was slowed down and a damper made for flue *d* and kept closed. Then the system operated as follows: All the air from the fan coils passed through the main floor openings and after the main floor was heated, the damper in duct *d* was opened partly to heat the balcony. A damper was also placed in exhaust duct *g*, and openings were cut in it to connect with air chamber *e*. Then on a zero day the theater was actually heated uniformly without running the fan at all. The air in airshaft *a* at zero was 30 per cent heavier than the air at 140 deg. in air chamber *c*; consequently, as fast as the air around the coils was heated it circulated through openings *f* to the main floor and entered duct *g*, and instead of exhausting to the atmosphere as formerly it passed into air chamber *e* and to the balcony through openings *h*, finally exhausting through the roof vents *i*.

The fuel saving was effected by reducing the weight of air that had to be forced out at 62 deg. or higher to permit air at outdoor temperature to enter the system. A further saving was made by not running the fan, which had formerly operated at full capacity during the noon hour.

A new rate schedule with the power company was entered into at this time, and as the maximum demand occurred at noon, due to heavy elevator traffic, the elimination of fan operation at that time was very desirable. It reduced the maximum demand by 13 kw. and permitted shutting down one stoker motor during the noon hour, still further cutting the power demand.



Calderwood hydro-electric station on the Little Tennessee River, North Carolina

MAINTENANCE METHODS

That Reduce Hydro-Plant Operating Costs

By J. ELMER HOUSLEY
Power House Superintendent
Tallassee Power Company

How the turbines and governors are inspected and maintained in three large hydro-electric plants on the same system, where a high degree of reliability is imperative

INSPECTION and maintenance are allies against breakdowns. Persistent and attentive inspection must be practiced by the operating men in hydro plants. Proper lubrication is one of the many things, if faithfully watched, that prevents failures from neglect. Proper inspection will prevent failures from loose or worn parts or faulty or deranged adjustments and will detect the critical period marking the beginning of a process that leads to equipment failure.

What are some of the things an operator can do to prevent breakdowns? Power of observation is the single requirement. By practice one is able to search with his eye every visible part of the equipment and note any looseness, leaks, vibration, wear, discoloration, smoke or unusual movement. The ear is able to detect and accurately locate the source of any change in the usual noise, such as pitch, volume, tone or the beginning of cessation of a sound.

The sense of feeling may be depended upon to a less accurate degree in noting changes in temperature of various parts which may be touched, such as bearings on pumps, motors, small generators and compressors. Packing glands give evidence of sensible heat and vibration when the wearing sleeves on the shaft have become grooved. Some parts, such as the pilot valve stem in some governors, have a certain freedom of movement that may be checked by touch, and if the valve becomes dirty or worn or out of adjustment, the slightest change is indicated thereby.

It is, of course, of no avail to make the inspection and find something not exactly right if the fact is not reported promptly. Prompt investigation and immediate correction must be made, and seldom should minor jobs be postponed. Habit in this matter determines whether an organization is "on its toes" or simply slouching along. An operator's ability is determined by his alertness and promptness in such work.

As a form of mechanical assistance to the operator and for his protection against forgetfulness, or that of others, a daily repair sheet is made out describing all adjustments and repairs. A monthly inspection report lists certain regular inspections, records the condition and wear of certain important details of the equipment. All equipment is not covered every month, but a definite time interval should be assisgned to every part, so that it will be inspected at the proper time determined by experience.

The governors in one group of plants are overhauled once a year. Sometimes no new parts are needed, but the dismantling process will detect any wear of the preceding year, and the ability of the parts to run another year may be accurately gaged. The flyballs and bearings are washed and lubricated by packing with petrolatum, except where the mechanism is lubricated by a continuous oil spray. All pin joints are examined for wear. The pilot valve and relay valves are examined for scoring due to leakage. However, the operator usually detects any leakage of valves by the behavior of the unit before

wire-drawing or scoring takes place. The strainer in the pilot valve system is cleaned every six months. The compensating cylinder is dismantled and cleaned, as dust and lint gets into certain types. It is refilled with new oil. Where a vibrating assembly is used to keep the governor system moving a slight amount continuously the device is examined for wear and replaced when necessary. The synchronizing or load-control operating motor is dismantled and cleaned by washing in gasoline, and all parts except the commutator are painted with air-drying insulating paint. All renewable bushings in the governor mechanism are examined, although it is only necessary to replace them at intervals, from four to eight years.

The oil used in the majority of governor systems will last indefinitely if given the proper care. Oxidation due to exposure to air, by foaming or spraying should be kept at a minimum. The oil must be filtered regularly and any sludge at the bottom of the sump tanks should be removed annually. The intervals between filtration vary with the service, but once in six months or annually will cover most installations.

Much information has appeared in the technical press concerning pitting of the runners of hydraulic turbines. Reports of the National Electric Light Association committee are valuable. Our practice is to make an annual inspection and by means of sketches set down the location of all pitted areas and their size and depth of pitting. When the depth reaches $\frac{1}{8}$ to $\frac{1}{4}$ in., the areas are welded. Cost is less by this method compared to waiting until the area requires an insert welded into the bucket.

On the annual inspection of the runner the clearance is measured between the rotating and stationary seal rings of the turbine at four points on the circumference. The clearance between the guide vanes is measured, and if there is any wear in the operating mechanism that might allow excessive leakage through the gates an adjustment is made. The interior of the scroll case and penstock is inspected to detect any corrosion, and it is painted if necessary. The buckets of the runner are carefully examined for small obstructions such as blocks of wood, small limbs from trees, and other objects.

On one 56,000-hp. unit a block of wood 2x4x10 in. lodged in a bucket. Although the vibration was imperceptible, due to the close fit of the turbine bearing, the unbalance caused loosening of the nuts on the ring bolted onto the top cover plate to carry the turbine bearing. A slight unbalance is readily detected on lignum vitae bearings on account of the larger clearance.

In another case a block of wood caused unbalance on a 27,000-hp. wheel and time could not be taken to unwater the penstock and remove the block. As a temporary remedy a 50-lb. weight was added to the rotor of the generator to compensate for the hydraulic unbalance in the runner, and the unit ran within the usual limit of 0.005 to 0.007 in. wobble instead of 0.02 in. before the counterbalance was added.

The lignum vitae bearing on three similar units have been in service from eight to eleven years. They are of the non-adjustable type, and wear has been limited by carefully checking the true running of the shaft daily with a dial indicator. When the shaft runs out of true more

REPORT NO. _____

INSPECTION REPORT
Hydraulic Turbine

LOCATION _____ DATE _____

MAKE _____ UNIT NO. _____

INSPECTED BY _____ DATE OF LAST INSP. REPORT _____

SCHEDULE - SYMBOLS (Annual - □) (Semi.Ann. -○) (Quarterly - △) (Mon. - x)

CK	Period	Part	Remarks	Last Insp.
	□	Turbine Bearing		
	x	Lubricating Oil		
	x	Oil Sump		
	□	Sump Pump (Viscosity)		
	x	Sump Pump (Motor Driven)		
	□	Turbine Shaft		
	□	Runner Blades		
	□	Runner Clearance		
	□	Draft Tube		
	□	Scroll Case		
	□	Guide Vanes		
	□	Guide Vane Clearance		
	x	Grease Cups		
	□	Packing		
	□	Packing Gland		
	□	Seal Rings		

REMARKS:-

Report form for hydraulic-turbine inspection

Report No. _____ Date _____

INSPECTION REPORT
HYDRAULIC GOVERNORS

Location _____ UNIT NO. _____

Make _____ Type _____

Inspected By _____ Date Last Inspection Report _____

Schedule Symbols - (Annual □) (Semi Annual - ○) (Quarterly - △)(Monthly - x)

OK	Period	Part	Remarks	Last Insp.
	□	Dash Pot		
	□	Pilot Valves		
	□	Fly Balls		
	□	Fly Ball Mechanism		
	□	Main Valves		
	x	Housing		
	x	Fly Ball Motor		
	□	Fly Ball Motor Bearings		
	x	Synchronous Motors		
	□	Hand Control Valves		
	□	Floating Lever Bushings		
	□	Solenoid		
	□	Servo Motors		
	x	Oil Piping		
	x	Oil Sump		
	x	Oil Pressure Tank		
	x	Oil		
	x	Gov. Pressure Oil Pump		
	□	Rotary Oil Pump Bearings		
	□	Unloader Valve		
	x	Air Connections		

General Remarks

Report form for turbine-governor inspection

TALLASSEE POWER COMPANY

DAILY REPORT OF REPAIRS MADE ON POWER HOUSE EQUIPMENT

Note—Make detailed report of any and all repairs made on gates, motors, and dam and power house equipment in general, using name and number of apparatus reported

_____ 19.

Signed _____
Operator in Charge

Daily report form for repairs made on power-house equipment

than the allowed amount the unit is balanced and brought back to the desired condition.

During annual inspection a check is made on each guide vane to see that the lubrication passages are open and grease is observed to run out of the joint inside the turbine. It was found necessary to go to a 2,500-lb. pressure lubrication pump and to the use of extra amber petrolatum to secure desirable lubrication of the turbine gates.

In connection with turbines using oil-lubricated guide bearings, suitable inclosures have been found necessary in some cases to prevent air circulation from carrying oil away from the turbine bearing and depositing it on the generator winding, a double loss.

The selection of packing is important on all revolving and reciprocating shafts. Sometimes a change may be made which will eliminate excessive leakage or undue wear on shafts.

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Switch Houses Designed For Exterior Operation

By F. E. JAQUAY

Switchgear Department
General Electric Company

A SWITCH HOUSE of novel design, having its first application as feeder equipment for electric shovels in a stone quarry, provides for exterior operation of apparatus instrument reading. Two circuits are controlled by individually operated oil circuit breakers and connections made to the feeders through roof-entrance bushings.

The relays, instruments and other equipment are mounted on a steel panel hinged at the left, Fig. 1, and arranged to swing outward to an angle of 90 deg. with the front of the house. This allows easy access to all back-of-panel wiring and connections. A triplex voltmeter mounted above the watt-hour meter indicates the voltage on the three phases, and the same type of ammeters, mounted vertically, indicate the current in each circuit. A watt-hour meter records total power consumption. At the center of the panel a tumbler switch makes connection to control power for the circuit breaker motor-operated mechanisms. There are four overcurrent relays, two for each circuit.

The doors are fitted with shatter-proof glass through which a full view is obtained of all relays and instruments. Under normal conditions the doors are closed and locked and operation of the two circuits is by small control switches mounted just above the doors, Fig. 1.

Fig. 1—Front view of switch house, showing circuit breaker operating mechanism, relays and meters

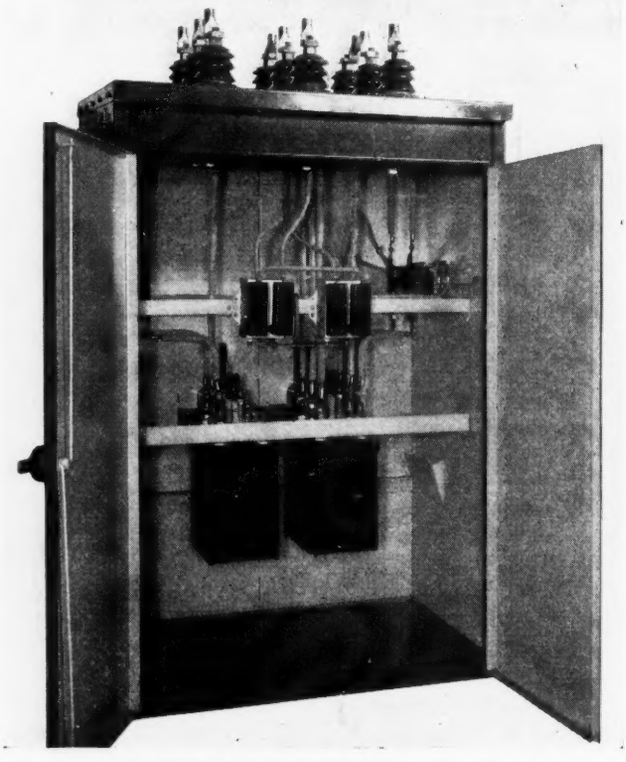


Fig. 2—Rear view of switch house, showing the two oil circuit breakers

Hydrogen Sulphide Corrosion In Natural Gas Engines

By V. L. MALEEV
Professor of Mechanical Engineering
Oklahoma A. and M. College

IN SOME of the oil and gas fields the presence of hydrogen sulphide in the gas has caused expensive engine cylinder replacement. This difficulty can be eliminated by the installation of the proper equipment.

At one time the writer, who was in charge of the engineering department of a California concern building gas engines, had an interesting experience with hydrogen sulphide.

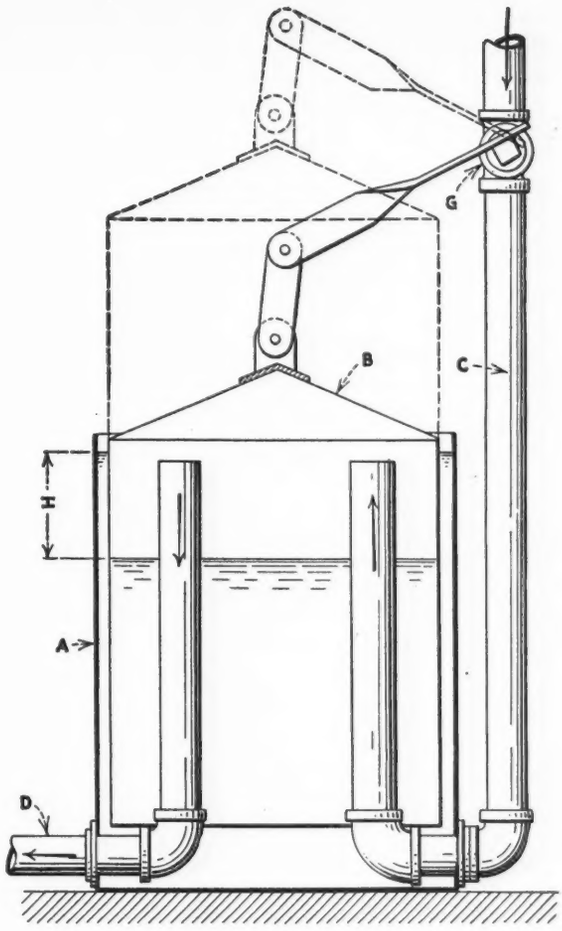
A Texas oil company had ordered six gas engines connected through short belt drives to compressors to be used for gas lift of oil wells. The successful operation of a number of oil wells depended upon uninterrupted operation of these gas compressors. They had to run day and night with as few and as short shutdowns as possible.

When the order was received an attempt was made to obtain complete information about the conditions under which the engines would operate, as these were the first engines to be installed in that part of the country. The available information was rather meager. The elevation of the power plant above sea level, the size, speed and discharge pressure of the compressors and that the customer had gas-pressure reducers and did not want to purchase gasometers were the gist of the data received. The only information in regard to the natural gas to be used as fuel was that its heating value was about 1,000 B.t.u. per cubic foot.

The writer's experience was that gas engines generally perform better when drawing the fuel gas through a gasometer. But if the gas-pressure regulator is properly adjusted and maintains a sufficiently low pressure engines perform just as well without a gasometer; therefore it was decided to comply with the customer's desire. Checking the load of the compressors, showed that the engines would be loaded close to full, but would not be overloaded. Not having indications to the contrary, it was decided to deliver engines with the same characteristics as were usually furnished for California oil fields, with a compression pressure at full load of 120 pounds per square inch, and with a mixing valve to give mixtures of gas to air from about 1 to 10 down to 1 to 15.

As soon as the engines were installed and started the erecting engineer began to report troubles. An engine would start, but after running for a while suddenly would have a heavy pre-ignition; then it would begin to slow down and finally would stop, or "die," as the engine operators call it. The stopping of one of the compressors increased the load on the remainder of the engines and they would begin to slow down and, if the load was not decreased promptly by partial closing of the valves in the compressor suction lines, the whole set of six engine-compressor units would stop. This happened several times a day, requiring close attention of the operators and considerably lowering production.

In addition, even while the engines were running without disturbance they sounded as though they were carrying an overload. Different readjustments of the gas-air mixing valves and retarding of the ignition did not help.



Design of gasometer in which ore absorbs the hydrogen sulphide

The next thing tried was a decrease of the compression. By inserting a ring 3.75 in. thick under the cylinder-head flange of one of the engines the compression ratio was decreased from 5.3 to 4.7. This practically eliminated the pre-ignitions and the consequences caused by them; but, on the other hand, naturally decreased the power of the engine, and the latter still gave evidences of overload.

The change which really helped was increasing the air admission to the mixing valve, first by drilling a hole in the mixing box for additional air admission, and, when this appeared very beneficial, by removing the standard mixing boxes and putting on mixing boxes designed for the next larger engine size. With the larger boxes the air admission was materially increased, the engines gained in power and the occasional pre-ignitions were unable to disturb their performance.

Another change was the addition of gasometers in the gas-feed line between the pressure regulator and the engines. The gasometer, illustrated, consists of a tank *A* containing water, over which is a second inverted tank *B*, called the bell. The gas enters through pipe *C* and flows to the engine through pipe *D*, with gas valve *G* controlled by the raising and lowering of bell *B*. The gasometer acts, then, as a surge tank to absorb the fluctuations in the gas flow, and it also creates a small pressure, which is measured by height *H*. Experience has shown that a pressure of from 6 to 9 in. of water, or from $3\frac{1}{2}$ to 5 oz. per square inch, insures the best engine performance.

With the gasometers installed the engines carried the load satisfactorily until a new trouble developed. After

about 160 hr. of operation the engines began to lose power, and an inspection showed that the spark-plug points were corroded. Other parts of the engine as valves and piston tops showed traces of corrosion, although not as pronounced as the comparatively thin spark-plug points. The spark plugs were exchanged, but the trouble occurred again after another 160 hr.

Absence of an analysis of the gas made elimination of the new trouble, which was caused by the presence of moisture in the gas from the gasometer, rather difficult. Fortunately the erecting engineer had mentioned that the gas was unusually ill-smelling and very toxic if inhaled even in a small amount. This information indicated that the gas probably contained hydrogen sulphide, which in the presence of moisture is very corrosive. To eliminate this action the gasometers were filled with crude oil instead of water, and the trouble from corrosion of spark-plug points and other parts was stopped. The engines since operated satisfactorily.

When the erecting engineer returned to Los Angeles he brought samples of the gas. Analysis showed a high percentage of hydrocarbons with large molecular weights and about 5 per cent of hydrogen sulphide. With these data it was easy to explain the troubles encountered when the engines were first started. The presence of heavy hydrocarbons requires more air than the California natural gas for which the mixing boxes were built. Both the heavy hydrocarbons and the hydrogen sulphide have rather low ignition temperatures, especially when compressed to 120 lb. per square inch. With the engines unable to deliver their full power on account of lack of oxygen and barely able to pull the compressors, each pre-ignition created a condition of excessive overload.

The percentage of hydrogen sulphide was unusually large, and the fuel gas was used without any attempt at removing this undesirable mixture. However, without the presence of moisture the gas did not produce corrosion sufficiently pronounced to make necessary the removal of hydrogen sulphide, which is done in other instances.

Methods of Removing Hydrogen Sulphide

There exist several methods of removing hydrogen sulphide from fuel gas. These methods were originally developed for use with the so-called artificial gas, produced from coal and sometimes from oil. Natural gas containing hydrogen sulphide, however, can be treated by the same methods and with the same results.

One of the older but efficient and comparatively inexpensive methods is based on the oxidation of hydrogen sulphide by air in the presence of iron oxide. Best results are obtained using a natural bog iron ore, $Fe_2O_3H_2O$. Fresh, this ore contains about 50 per cent water and a large amount of vegetable matter. It is dried, to remove about one-half of the water, and mixed with an equal amount of sawdust to render it more porous, thereby reducing the resistance for the gas flow. The chemical reactions which take place probably run in two directions

$$Fe_2O_3 + 3H_2S = Fe_2S_3 + 3H_2O$$

and

$$Fe_2O_3 + 3H_2S = 2FeS + S + 3H_2O$$

Modern chemists call these reactions preferential combustion. They take place at low temperatures and are materially assisted by the catalytics, in this case F_2O_3, being in colloidal form, as it is the case with bog-iron ore.

These reactions are conducted in purifiers, which consist of fairly large rectangular cast-iron boxes in which the iron-ore mixture is placed in two layers about 30 in. thick supported by wooden screen-shaped shelves; a cast-iron lid of the shape of an inverted box with a water seal prevents the gas from escaping. Usually, four or six purifiers are set in series to insure better removal of the hydrogen sulphide. When the oxide has become saturated it is removed from the box and exposed to the air, where, under the influence of the atmospheric oxygen, ferric oxide is formed and sulphur is set free. The rejuvenated ore is put back into the purifier and used until the sulphur content reaches about 50 per cent, when the ore must be renewed.

In later designs the oxidizing mixture is put into two or three large, round boxes, built either of steel or concrete and placed out of doors to save the expense of a building. In this case the oxide is put 10 to 15 ft. deep, and its rejuvenation is carried out in the boxes themselves by blowing air through the oxide, for which purpose the gas piping must be properly arranged with bypasses and valves. The size and number of the flat boxes are selected to give about 0.65 sq.ft. absorbing area per 1,000 cu.ft. gas per 24 hr. In the new, large boxes about 3.9 cu.ft. of oxide is used for the same amount of gas.

An entirely different method of liquid purification has been introduced recently by the Koppers Company. In this method the gas is washed or scrubbed with a 2 or 3 per cent solution of sodium carbonate, in a tower filled with coke or wooden grids. The hydrogen sulphide combines with the sodium carbonate and remains in the solution. The foul solution is later actified, or rejuvenated, by blowing it into a second scrubber with a strong blast of air. The actifying scrubber must have 20 per cent more filling than the absorbing one, and the volume of air blown through must be from three to five times larger than the volume of gas cleaned. The excess of air reverses the reaction and carries H_2S out of the solution, the air discharging from a high stack to secure proper diffusion. From 60 to 80 gal. of sodium solution is used with each 1,000 cu.ft. of gas. Part of the sodium goes into inactive salts and must be replaced by fresh soda. Water must be also added from time to time, chiefly in the actifying scrubber, to make up for evaporation. The consumption of soda depends upon the composition of the gas treated, but under most adverse conditions should not exceed 0.1 lb. per 1,000 cu.ft. of H_2S removed.

To avoid an intermediate pump for the solution the absorbing scrubber is sometimes put on top of the actifying one and the solution from the first scrubber flows by gravity through the coke layer in the second scrubber and from there to a sump, from which it is pumped again to the top of the absorbing scrubber. In an installation with a capacity of 1,000,000 cu.ft. of gas per day the total height of the scrubbers is made about 28 ft., with layers of coke 12 ft. high in the first and 14 ft. in the second scrubber; the diameter of this tower is about 6 ft. Air is removed through a steel stack 75 ft. high from the base, made from 14-in. casing and supported by a number of guy ropes. The air is furnished by a fan blower with a pressure of 6 in. of water.

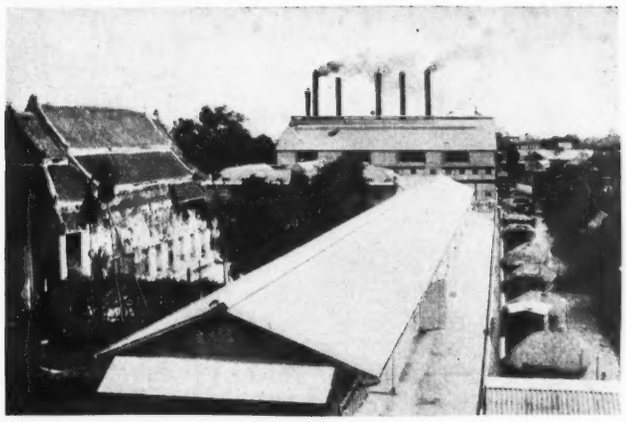
The operation of such an installation is not expensive, and the only difficulty is with the air carrying H_2S. Even when a high stack, and sufficient air is used to bring the concentration of H_2S to less than 0.08 per cent, complaints have resulted from the odor. In some plants arrangements are made to use the air under the boilers. This is not very desirable, on account of corrosion of the boilers.

IN FAR-OFF SIAM

By WALTER BUCHLER

THE POWER STATION of the Siam Electric Corporation, in Bangkok, was the first to be established in Siam. It was built in the early nineties and was taken over by a private concern in 1898, when the Siam Electricity Company, Ltd., was formed. It continued operating as an electric light and tramway concession up to 1927, when it was amalgamated with the Siam Electric Corporation. There is one other large power station in Siam, the Samsen power station, belonging to the government and supplying current to the southern section of Bangkok, including the royal palaces, the waterworks and the Siam Cement Company, Ltd. During the past five years numerous oil engine plants have been erected in the smaller towns, but these are small compared with that of the Siam Electric Corporation's power station in Bangkok, which has 16,000 kw. capacity and is the biggest in Siam. It has two 5,000-kw. Ljungström turbines, two 2,000-kw. units of the same make, and two 1,200-kw. A.E.G. machines. It generates 3,600-volt, 3-phase current at 50 cycles, which is converted into 550-volt direct current by three A.C.E.C. (Atelier de Construction Electrique de Charleroi) 800-kw. synchronous motor-generators. Everything in the power station is more or less new, including the high-tension switchboard with its special switchboard house and high-tension cells. The turbine-generators are cooled by filtered air.

The turbines are supplied with steam at 200 lb. pressure, which is generated by six B. & W. cross-drum boilers, each capable of producing 31,250 lb. per hour. As fuel, paddy husk is used practically the whole year round. This is the husk from rice, obtained from the rice mills, and has a calorific value of 5,300 B.t.u. per lb.



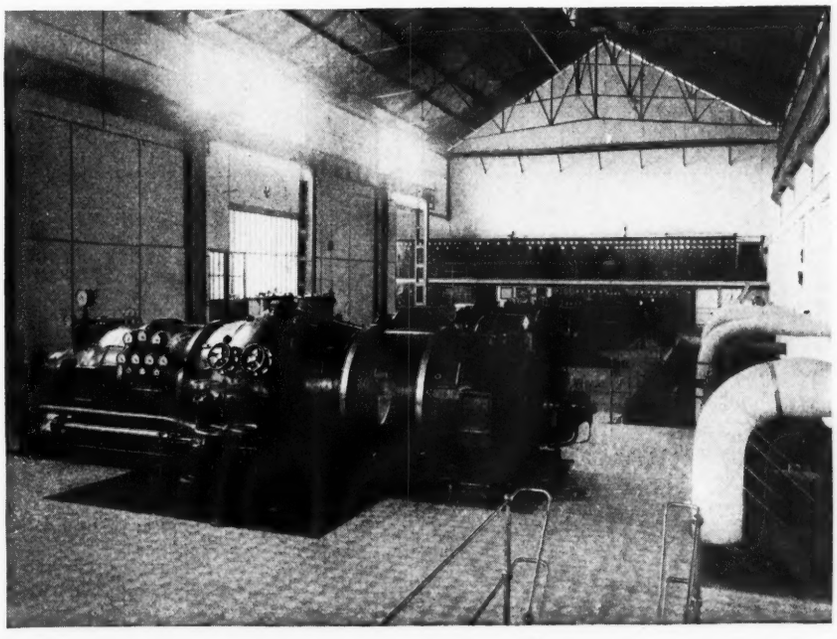
This view gives an idea of the power house surroundings

In times when there is a shortage of paddy husk, as when the old crop has been milled and before the new crop has come in, crude oil is used as a substitute.

Rice milling in Siam is becoming more and more centralized, and the present tendency is to mill in Bangkok only rice intended for export. Hence paddy husk is getting more and more scarce, with the result that the company decided to convert one boiler to burn coal and to install another similarly equipped. It is intended to import the coal from Sumatra, Indo-China or Bengal. The cost of using coal will be slightly higher than paddy husk, though it will be considerably cheaper than oil.

While kerosene oil is still used extensively in sections where no electricity is available, and by those too poor to afford electricity, consumption of the latter has steadily increased in recent years till the present trade depression caused a temporary halt. The annual consumption for all purposes in Bangkok, including tramways, is now approximately 28 million kilowatt-hours, the private power station supplying 16 million of this.

The power station is located along a canal leading to the river. In this way fuel is brought to the station by barge and condensing water is at hand. Because of the tropical temperatures the condensers are unusually large.



Turbine room of the Siam Electric Corporation's power station in Bangkok. It contains several radial-flow units. The station, largest in Siam, has a total capacity of 16,000 kilowatts

FUSE PERFORMANCE
in Circuit-Interrupting Service

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The fuse considered in its ability to interrupt a circuit, and the factors that influence its performance in that duty. The results of a series of overload tests made on different size fuses are given. A second article will treat of fuse performance in relay service.

THE circuit-interrupting device should receive prior consideration when contemplating protective equipment. It is the element that must clear the fault, the other devices serving principally as a means of control. It is therefore desirable to give first attention to the various types of circuit interrupters with particular reference to their construction, operation and application. Circuit-interrupting devices may be divided into three classes: Fuses; thermal cutouts; and circuit breakers.

A fuse has the combined properties of a circuit interrupter and a relay. It serves to open the circuit on excess current and delays this action inversely in proportion to the current's magnitude. In other words, the time required to "blow" a fuse is less for large than for small currents. This is known as the inverse-time characteristic. Simplicity and low initial cost render the fuse particularly adaptable for the protection of low-capacity, low-voltage circuits. These admirable qualities should not lead to indiscriminate application, because fuses have their limits, although these may not always be obvious or well defined.

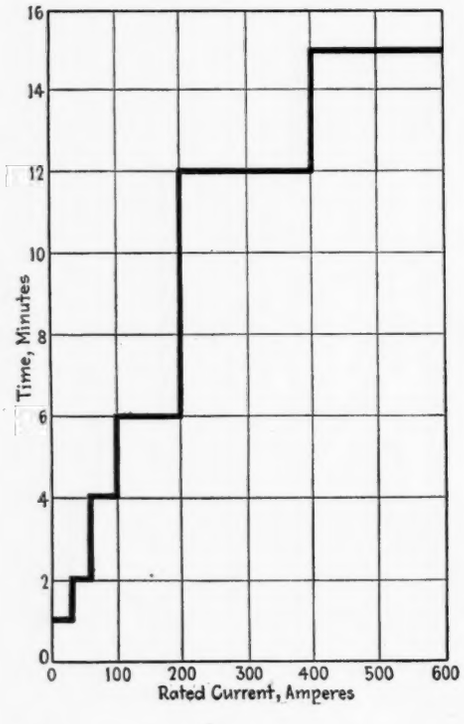
The properties as a circuit interrupter and relay may be discussed separately to good advantage, as this will avoid confusion in arriving at a clear conception of the limitations of each.

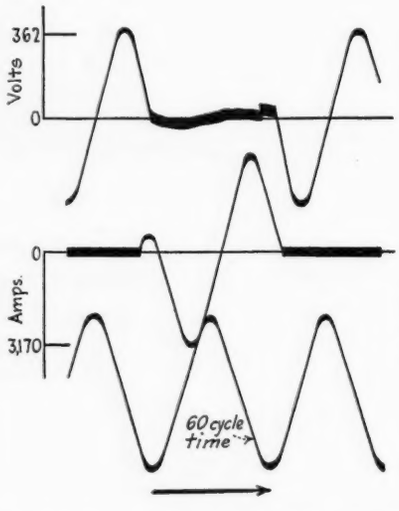
As a circuit-interrupting device the items of chief interest are:

1. Normal rated capacity (voltage and current).
2. Overload capacity.
3. Short-circuit capacity.
4. Reliability.
5. First cost.
6. Maintenance.

1. *Normal Rated Capacity*—Aside from special applications, such as protecting instrument transformers and small-capacity circuits fed from high-voltage systems by expulsion-type fuses, the great majority of fuse applications are on circuits of 600 volts and less. This discussion will be confined to the use of fuses in the latter class of service.

As the maximum standard current rating of 600-volt





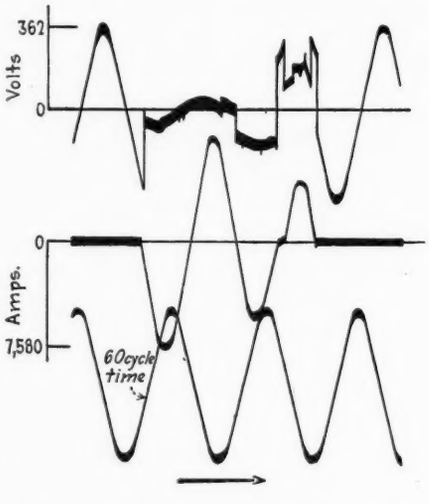


Fig. 1 (Left)—Time in minutes required for fuses of different sizes to blow when carrying 150 per cent rated current

Fig. 2 (Center)—Oscillograph record of a test made at 60 cycles on a 150-amp., renewable-type, 250-volt fuse, typical of a successful interruption

Fig. 3 (Right)—Oscillograph record of a test made on a 400-amp., 250-volt renewable fuse, clearly indicating re-ignition of the arc which delayed interruption of the circuit

cartridge fuses is 600 amp., their application is limited to a circuit capacity of:

$$\frac{600 \times 600}{1{,}000} = 360 \text{ kva. single-phase.}$$

$$\frac{600 \times 600 \times \sqrt{3}}{1{,}000} = 623 \text{ kva. three-phase.}$$

$$\frac{600 \times 600 \times 2}{1{,}000} = 720 \text{ kva. two-phase, four-wire.}$$

Circuit capacities which can be protected by fuses are, of course, proportionately reduced at correspondingly lower voltages.

Two or more fuses may be connected in parallel, but this is poor practice. The low resistance of fuses, particularly in the larger sizes, makes it difficult to secure equal current division in the assembly, due to variations in contact resistance. The fuse having the lowest overall resistance will carry more than its share of the current and this will cause it to blow. The remaining fuses then become overloaded and also blow, causing an unnecessary interruption to service.

2. *Overload Capacity*—Standard specifications established by the National Board of Fire Underwriters require that a fuse shall: (*a*) carry indefinitely 110 per cent rated current at an ambient temperature of 24 deg. C. without causing the inclosing tube to char or externally visible soldered connections to melt; (*b*) blow on 150 per cent rated current within a specified time. This time varies from 1 to 15 min., according to the size of fuse as given in Table I. The values in this table are plotted in Fig. 1.

The current-carrying capacities allowed for various fuse element sizes are such that 10 per cent overload can be carried continuously without injury, and most motors have the same safety margin. The 10 per cent margin allowed for continuous rating of fuses is therefore safe when selected with regard to the rated capacity of the circuit or motor with which they are to be used.

Greater time limits for the large fuses than for small fuses are permissible because large-sized conductors or motors have a correspondingly larger heat-storage capacity and can stand overloads for a greater length of time without injury.

When the current exceeds the fuse rating the weakest portion of the link will melt. The gap is not sufficiently long at first to open the circuit, and an arc exists until sufficient metal has melted to increase the gap to where an arc cannot be maintained. The powder used in some non-renewable fuses assists in quenching the arc by cooling the metallic vapor and by mechanical displacement of the arc.

Various metals, such as zinc, lead, aluminum and alloys may be used for the fusible element, some being better adapted than others for this purpose. A proper balance between fusing temperature, conductivity, mechanical strength and arcing properties must be secured for most satisfactory operation. The current required to fuse several different metals is given in Table II. The values given in the table are no measure of melting temperatures. For example, the melting point of copper is 1,996 deg. F., lead 773 deg. F., but the cross-section of copper fused by a given current is much less than that of lead for the same current.

TABLE I—TIME IN MINUTES REQUIRED FOR FUSES TO BLOW WITH 150 PER CENT RATED CURRENT

Fuse Size, Amp.	Time to Blow on 150 Per Cent Current, Min.	Fuse Size, Amp.	Time to Blow on 150 Per Cent Current, Min.
0- 30	1	101-200	6
31- 60	2	201-400	12
61-100	4	401-600	15

3. *Short-Circuit Capacity*—Standard inclosed fuses must be capable of interrupting short-circuit currents of at least 10,000 amp. at their rated voltage without emission of sufficient flame or molten metal to ignite easily inflammable material entirely surrounding the cartridge, the latter to remain intact. This constitutes the minimum requirement, and unless a rupturing capacity in excess of 10,000 amp. is specifically guaranteed it cannot be expected to exceed this figure greatly.

Metallic vapors, produced by the fusible element volatilizing under short circuit, are generated at such a rate and in such quantities that considerable pressure develops in the cartridge. This pressure is usually relieved, and the gases are cooled by vents at the cartridge ends. The cartridge size and vent design must be so proportioned that pressure will not develop to where they will rupture. At the same time, the venting must be designed to cool the vapors sufficiently to avoid flame emission.

A fuse's ability to rupture current under short-circuit conditions may best be determined by test. The standard test is to connect the fuse to a storage battery capable of delivering 10,000 amp. at the fuse's voltage rating, precautions being taken to limit the inductance of the circuit to a minimum. Inductance in an electric circuit tends to maintain the current when the circuit is opened, and therefore imposes a more severe duty on fuses when

TABLE II—CURRENT IN AMPERES REQUIRED TO FUSE WIRES OF DIFFERENT MATERIALS[1]

Current in amperes	Copper, a=10 244	Aluminum, a=7 585	Platinum, a=5 172	German silver a=5 230	Platinoid, a=4 750	Iron, a=3 148	Tin, a=1 642	Tin-lead alloy a=1 318	Lead, a=1 379
1	0.002 1	0.002 6	0.003 3	0.003 3	0.003 5	0.004 7	0.007 2	0.008 3	0.008 1
2	0.003 4	0.004 1	0.005 3	0.005 3	0.005 6	0.007 4	0.011 3	0.013 2	0.012 8
3	0.004 4	0.005 4	0.007	0.006 9	0.007 4	0.009 7	0.014 9	0.017 3	0.016 8
4	0.005 3	0.006 5	0.008 4	0.008 4	0.008 9	0.011 7	0.018 1	0.021	0.020 3
5	0.006 2	0.007 6	0.009 8	0.009 7	0.010 4	0.013 6	0.021	0.024 3	0.023 6
10	0.009 8	0.012	0.015 5	0.015 4	0.016 4	0.021 6	0.033 4	0.038 6	0.037 5
15	0.012 9	0.015 8	0.020 3	0.020 2	0.021 5	0.028 3	0.043 7	0.050 6	0.049 1
20	0.015 6	0.019 1	0.024 6	0.024 5	0.026 1	0.034 3	0.052 9	0.061 3	0.059 5
25	0.018 1	0.022 2	0.028 6	0.028 4	0.030 3	0.039 8	0.061 4	0.071 1	0.069
30	0.020 5	0.025	0.032 3	0.032	0.034 2	0.045	0.069 4	0.080 3	0.077 9
35	0.022 7	0.027 7	0.035 8	0.035 6	0.037 9	0.049 8	0.076 9	0.089	0.086 4
40	0.024 8	0.030 3	0.039 1	0.038 8	0.041 4	0.054 5	0.084	0.097 3	0.094 4
45	0.026 8	0.032 8	0.042 3	0.042	0.044 8	0.058 9	0.090 9	0.105 2	0.102 1
50	0.028 8	0.035 2	0.045 4	0.045	0.048	0.063 2	0.097 5	0.112 9	0.109 5
60	0.032 5	0.039 7	0.051 3	0.050 9	0.054 2	0.071 4	0.110 1	0.127 5	0.123 7
70	0.036	0.044	0.056 8	0.056 4	0.060 1	0.079 1	0.122	0.141 3	0.137 1
80	0.039 4	0.048 1	0.062 1	0.061 6	0.065 7	0.086 4	0.133 4	0.154 4	0.149 9
90	0.042 6	0.052	0.067 2	0.066 7	0.071 1	0.093 5	0.144 3	0.167 1	0.162 1
100	0.045 7	0.055 8	0.072	0.071 5	0.076 2	0.100 3	0.154 8	0.179 2	0.173 9
120	0.051 6	0.063	0.081 4	0.080 8	0.086 1	0.113 3	0.174 8	0.202 4	0.196 4
140	0.057 2	0.069 8	0.090 2	0.089 5	0.095 4	0.125 5	0.193 7	0.224 3	0.217 6
160	0.062 5	0.076 3	0.098 6	0.097 8	0.104 3	0.137 2	0.211 8	0.245 2	0.237 9
180	0.067 6	0.082 6	0.106 6	0.105 8	0.112 8	0.148 4	0.229 1	0.265 2	0.257 3
200	0.072 5	0.088 6	0.114 4	0.113 5	0.121	0.159 2	0.245 7	0.284 5	0.276
225	0.078 4	0.095 8	0.123 7	0.122 8	0.130 9	0.172 2	0.265 8	0.307 7	0.298 6
250	0.084 1	0.102 8	0.132 7	0.131 7	0.140 4	0.184 8	0.285 1	0.330 1	0.320 3
275	0.089 7	0.109 5	0.141 4	0.140 4	0.149 7	0.196 9	0.303 8	0.351 8	0.341 7
300	0.095	0.116 1	0.149 8	0.148 7	0.158 6	0.208 6	0.322	0.372 8	0.361 7

[1]This table was compiled by W. H. Preece, F.R.S., and is based on the formula $d = \left(\frac{c}{a}\right)^{\frac{3}{2}}$, where d is the wire's diameter in inches, c the current in amperes and a a constant given at the top of each column for the different materials.

opening the circuit. This effect will, of course, vary with the amount of inductance in the circuit. Except on unusually high capacity circuits there is generally sufficient resistance to limit the current to values below 10,000 amp., so that a test current of this value delivered over a non-inductive circuit meets practically all requirements ordinarily encountered.

A current of 10,000 amp. corresponds to a circuit resistance of 0.06 of an ohm at 600 volts, or 0.025 ohm at 250 volts. While these low values will not ordinarily be obtained on moderate- or high-capacity circuits of considerable length, still lower values may exist where there is a large concentration of power. For example, if a three-phase 440-volt bus is connected by short heavy conductors to a transformer bank of 1,000 kva. capacity, and nearly normal high-tension voltage is maintained at the primary terminals, the low-tension short-circuit current may reach 20,000 kva., or 26,000 amp. at 440 volts. Obviously, circuit breakers should be used in preference to fuses for this service. The duty is not only 2.5 times a fuse's rated rupturing capacity, but the circuit is highly inductive, further decreasing the probability of clearing the trouble without damage to the fuse and adjacent apparatus.

Results of fuse tests on direct current under short-circuit conditions are shown in Table III, the time required to clear the circuit being measured by an oscillograph. A large-capacity storage battery and test connections designed to limit the inductance of the test leads to a minimum value were used in making the tests. As indicated in the table, only one cartridge failed out of twelve tests below 10,000 amp., whereas three failed out of seven tests at currents in excess of that value. It may therefore be inferred that successful clearance of the circuit cannot be consistently obtained at currents greatly in excess of the minimum requirement. The high rate of current rise under short-circuit conditions indicates that appreciable voltages may develop when the circuit ruptures.

Fig. 2 is an oscillograph tracing of a test made at 60 cycles on a 150-amp., renewable-type, 250-volt inclosed fuse, and is a typical example of a successful interruption. Fig. 3 is a similar test on a 400-amp., 250-volt, renewable fuse, and clearly indicates re-ignition of the arc which resulted in delayed action, although the circuit was cleared at the end of the second half cycle.

4. *Reliability*—The reliability of a fuse, considered in the usual sense as that property which renders it free from disorders, is probably greater than any other piece of protective equipment, provided it is not applied to a duty beyond its capacity and is correctly installed and maintained.

5. *First Cost*—The first cost of fuses is lower than that of any other circuit-interrupting device within the range of applications for which they are adapted. This renders them particularly desirable for many low-capacity applications.

6. *Maintenance*—Maintenance of fuses is largely associated with their replacement. Unlike other protective devices, except possibly the thermal cutout, a fuse requires replacement after each operation. This expense has been reduced by using renewable links, effecting considerable savings in fuse replacements, particularly in the larger sizes.

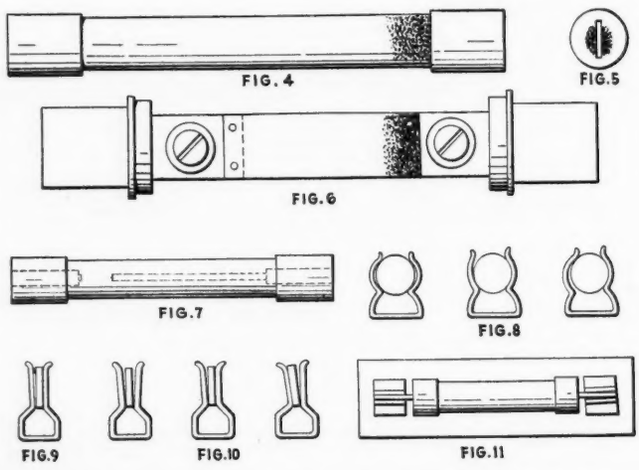
For general-purpose circuits, such as lighting, control, fractional-horsepower motors subject to infrequent overloads and where a comparatively short interruption of service is unimportant, the maintenance expense of fuse replacements is so low that no other protection is economically comparable.

For larger-capacity circuits or those subject to frequent overloads, an automatic circuit breaker will usually be found more economical. While no sharp dividing line can be drawn, a comparison between the two types of protection may be obtained by balancing the capitalized cost of fuse renewals per year against the cost of an automatic circuit breaker. If other factors are involved, such as lost time and production occasioned by delay in fuse replacements, they should be included.

When fuses are used to protect circuits where service continuity is of great importance, it is the practice of some companies to make regular semi-annual or annual tests. This work is conveniently executed by replacing all fuses with those that have been tested. If fuses are of the non-renewable type the test may consist of visual inspection for evidence of overheating, corrosion, charring, etc., and measurement of resistance. If fuses are of the renewable type, the internal condition may also be inspected. Among the important applications where this type of maintenance is justified are:

1. Control circuits of important machines or feeders.
2. Lighting circuits in places where interruptions would be hazardous to life, such as hospitals, theaters and other places of public assemblages.
3. Circuits supplying power where a short interruption would result in damage or complete loss of material being manufactured.
4. Railway-system signal circuits or similar applications where service interruption would be costly or dangerous.
5. Circuits metering large quantities of power.

The economic loss resulting from unnecessary blowing of fuses is without question the greatest item of expense chargeable to maintenance. It is therefore important that careful attention be given to their selection, application and maintenance if full advantage of low first cost and simplicity of fuse protection is to be realized.



FIGS. 4 TO 11—TYPICAL EXAMPLES OF FUSE TROUBLE RESULTING FROM POOR CONTACT

Fig. 4—Tube charred and terminal discolored because of poor contact at the clips. Fig. 5—Washer or end ring burned on renewable fuse caused by cap not being screwed down tight. Fig. 6—Charring of fiber bar in renewable fuse, caused by poor fuse contact. Fig. 7—Non-refillable fuse melted at one end because of poor contact. Fig. 8—Distorted or bent ferrule clips are a common cause of fuses overheating due to insufficient contact. Fig. 9—Arc bead on fuse clip causes poor contact. Fig. 10—Bent knife-blade clips and fuse terminals out of line cause poor contact. Fig. 10—Fuse clips out of alignment on terminal block cause poor contact.

TABLE III—SHORT-CIRCUIT TESTS ON FUSES WITH DIRECT CURRENT

Fuse Rating, Amp.	Fuse Type	Seconds to Clear Circuit	Peak Current, Amp.	Avg. Rate of Rise Amp. per Sec.	Test Voltage
30	Renewable	0.003	2,380	1,560,000	257
30	Renewable	0.003	2,380	1,780,000	257
30	Non-renewable	0.004	2,830	1,260,000	254
30	Non-renewable	0.003	2,940	1,530,000	257
60	Renewable	0.005	4,190	1,550,000	258
60	Renewable	0.005	4,260	1,510,000	257
60	Non-renewable	0.009[1]	6,540	1,050,000	258
100	Renewable	0.007	5,990	1,540,000	258
100	Non-renewable	0.011	6,930	1,250,000	260
100	Non-renewable	0.011	6,970	1,340,000	256
200	Renewable	0.013	9,350	1,300,000	257
200	Renewable	0.013	9,700	1,440,000	257
200	Non-renewable	0.017[1]	12,900	1,350,000	258
200	Non-renewable	0.018[1]	12,640	1,300,000	257
400	Renewable	0.017	13,650	1,210,000	252
400	Non-renewable	0.024	17,540	1,190,000	257
400	Non-renewable	0.023	16,680	1,150,000	257
600	Renewable	0.032[1]	14,000	1,330,000	256
600	Non-renewable	0.029	21,080	1,010,000	257

[1] Fuse cleared circuit but fiber case burst.

Poor contact either in the fuse itself or at the terminal mounting is the most common cause of faulty fuse operation. Any contact trouble will cause local heating and result in premature blowing. These conditions can easily be recognized by inspection or determined by a comparatively simple test to check contact pressure or surface.

Burning or charring of fuse cases is the result of poor contact. The lack of good contact may be a result of poor design or other defect in the construction of the fuse, improper renewal, overfusing, abuse or lack of attention to fuse clips and fuse blocks.

When a fuse blows the cause is usually an overload on the protected equipment or excessive contact resistance in the fuse or its terminal connections, although high ambient temperatures have been known to cause fuses to blow at less than rated current. Assume that the proper size of fuses has been selected, a careful check should be made to determine the cause of the trouble before making replacements. Common causes of trouble in fuses are indicated in Figs. 4 to 11, and the remedy is obvious.

If the fuse protects a motor circuit, the trouble may be in the wiring, the motor, or because of too great a load. Probably the greatest source of trouble is overloads. Some of the most common causes of overloads are tight belts, lack of lubrication in the motor or bearings of the driven machine; brushes improperly set on the commutator; motor started too quickly; and starting under heavy load, such as when material piles up on a conveyor or a crusher is filled with material.

Overfusing to eliminate annoying interruptions is not the proper remedy in any case. Using too large fuses gives practically no protection against normal overloads and defeats the whole purpose of protection. Furthermore, it is a hazard to life and property.

If higher-capacity fuses are needed and will properly protect the circuit and the machine, larger fuse blocks should also be installed. Using oversized links in renewable fuse cartridges is to be avoided, because the terminals and other parts are designed for a specific current value and can not be loaded greatly in excess of this without overheating.

Installation of oversize links in renewable cartridges may result in complete failure when a short circuit occurs, since the pressures generated by volatilizing the excess metal may cause the cartridge to explode.

Drilling holes in the sides of fuse cartridges to lower the temperature is also hazardous. A fuse treated in this manner is more liable to explode than one without the holes. This may appear illogical on first thought, but consideration of the action under short circuit will explain it. The high pressure generated in the tube under short circuit sweeps the metal vapor at high velocity through the arc and out through the vents at the end of the tube, where the gas is cooled by contact with comparatively cool metal. This action has a large part in quenching the arc under heavy short circuits. If holes are drilled in the sides of the tube the pressure is lowered and the gases are diverted from the path in which they are most effective in quenching the arc, thus lowering the rupturing capacity. The presence of the holes allows the emission of hot gases and the expulsion of molten metal, which may ignite inflammable material near the fuse. Where larger fuses are required the only satisfactory and safe practice is to install equipment designed to meet the increased duty.

A future article will discuss the performance of fuses as relays.

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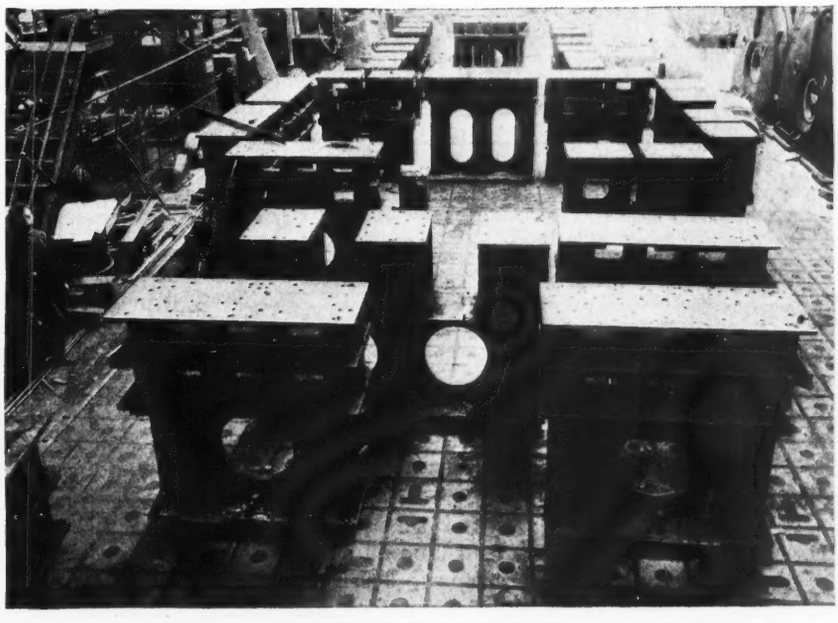


THESE are not ruins of the ancient buried city of Pompeii but steel foundation blocks on which turbines are placed for assembly and test in the Schenectady works of the General Electric Company

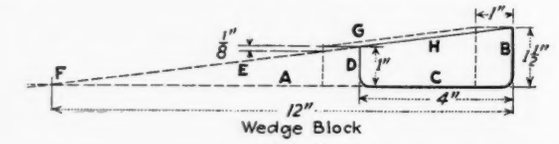
...RIGHT OUT OF THE PLANT...

Proper Adjustment of Crankpin Box

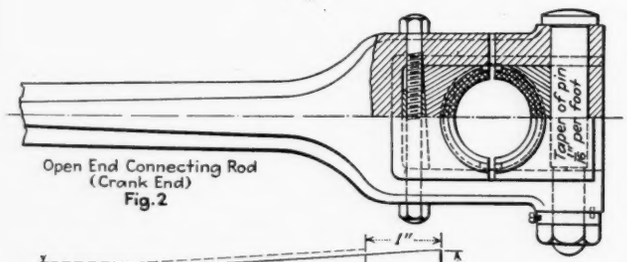
THE ILLUSTRATION, Fig. 1, shows a wedge block of 6 in. per 1 ft. scale. To determine the displacement of the block it is not necessary to draw in the dotted lines *AFG*. Simply draw indefinite lines *B* and *C* at right angles. Place wedge block fair with these lines as shown and draw a line around its edges. Move the block along line *C* 1 in. and draw another line along *H*, producing dotted line *G*. Then measuring *HG* parallel to *B* will give the displacement of the wedge block per inch, in this case $\frac{1}{8}$ inch.

Next measure the pitch (number of threads per inch) of the adjusting screw, which in this case is ten. Then, with a pencil place a mark on the rod fair with one of the angles of the head of the screw, which is usually a hexagon, and, turning ten complete turns, will displace the wedge one inch, and, of course, displace the wedge-half of the box $\frac{1}{8}$ in., or 0.125 in.

Then if only one complete turn of the screw is made, a displacement of $\frac{1}{10} \times \frac{1}{8} = 1/80$ in., 0.0125 in., will result. Likewise, if the screw is turned only one hexagon or $\frac{1}{6}$ of a turn, a displacement of 1/480 in., or 0.002 in. will result. And with one-half of a hexagon a displacement of 1/960 in. is obtained, or a little more than 1/1000, or 0.001 in., which is ample refinement.



Wedge Block
Fig.1



Open End Connecting Rod
(Crank End)
Fig.2

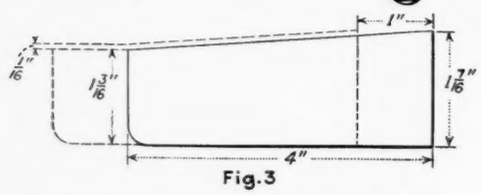


Fig.3

Knowing the displacement of the wedge block facilitates proper adjustment of the bearing

Although no single adjustment such as one "hex" may be such as required, yet you know just what you have done.

The underlying thought may be carried into various angles of adjustment, as, for instance, the adjustment of the "quarters" of the crankshaft bearing. It is a common remark, "I have tightened or loosened (as the case may be) her a 'little' bit," but just how much or how little?

Fig. 2 shows the crank end of an open-ended connecting rod. Fig. 3 is an enlarged drawing of its wedge block. It will be seen that the displacement of the wedge block is one-half that of the block shown in Fig. 1.

In my opinion, there should be a steel plate covering the full face of the "brass" carried between it and the wedge, to prevent the possible chafing of the "brass" by the wedge.

WM. PITTMAN.

Granite City, Ill.

Care of Rotary-Type Mechanical Oil Burners

OF CONSIDERABLE IMPORTANCE in the proper operation of mechanical oil burners of the rotary type is the care of the burners while out of service. This applies especially to small plants where the fires are put out each night. It is the practice of many engineers to place the burner in a bucket of kerosene and leave it soaking until it is wanted. Kerosene will easily dilute the heavy fuel oil and any gummy residue left in the burner, but the burner should not be left in the kerosene indefinitely. In a plant that shuts down every night the burner should be removed from its mounting as soon as the air is shut off, to prevent excessive heating from the radiation of the furnace. If the oil is shut off several minutes before the air it will drain the feed tube and bowl, making cleaning much easier. The burner should be dismantled and thoroughly cleaned with a brush and kerosene. If possible it should then be blown out with air. All bearings should be lubricated with light machine oil and placed in a rack to drain.

In many plants at least one spare burner is kept on hand. It should be kept clean and ready for operation at all times.

When removing or handling the burner care should be taken not to strike it against anything to dent or scratch the brass bowl, as any distortion in its edge will result in improper atomization.

In operation, any accumulation of carbon under the burner should be broken up with a bar and removed, because it will be likely to cause overheating. The reason for any such accumulation should be determined if it forms in excessive amounts. Probably it will be found to be due to one or more of the following conditions:

dirty or damaged burner, poor quality of oil, wrong proportion or ratio of air-oil supply, wrong oil temperature, or wrong size of burner tip for load carried. The temperature regulator may be set for good operation with one particular oil, but the next carload may vary enough to require a different setting.

Millford, N. J. HARRY M. SPRING.

Why Air Agitation in Ice Cans?

ON PAGE 24 of the July 7 number, the question is asked "Has anyone proved by impartial tests that raw water properly filtered, will not make sanitary ice without air agitation?"

My experience is on the negative side. In 1895, when a student at Washington University, we made analyses of ice from each commercial source that was offered for sale in the city of St. Louis, with some startling results. There was a plate ice plant in East St. Louis and a number of can plants in St. Louis. Also a great deal of ice was gathered from natural sources, and we checked the origin carefully. At that time ice was cut in winter, weather permitting, from large ponds and abandoned quarries in St. Louis; but as this was used for cooling and not offered to the trade we did not include it in any reports, but made analyses for comparative purposes.

Judged by the bacterial count, the best was from the plate ice plant. Second, and not far behind, was artificial ice made by one plant in St. Louis, and natural ice cut from Lake Pepin in the Mississippi River. The worst was made by a brewery in St. Louis, and was so far worse than half a dozen students checked each other and a variety of samples was obtained from the same place.

As a further check, I went to Peoria, Ill., and took a sample from an ice house which was filled from Lake Peoria (in the Illinois River). At this time the Chicago drainage canal was not in operation, but some sewage was pumped into Des Plaines River, in the western part of the city, so that at Joliet it was a foul stream at low water. To our surprise, this ice was relatively free from contamination, showing that the old contention that water tends to purify itself by freezing is true. I have forgotten the exact bacterial count, but it is a matter of record at the university. This Peoria ice was not worse than others cut in apparently more favorable places.

Summing up, our work showed that it is possible to make sanitary ice by the can process, also that it is possible to make sanitary raw-water ice without agitation by filtering the water. The East St. Louis plant previously referred to pumped from the Mississippi and filtered only, using no coagulants or sterilizing agents.

Natural ice may be sanitary even if cut from water containing unsanitary impurities. From a standpoint of freedom from bacteria, the rank is: Plate ice, well-made can ice, natural ice, carelessly made can ice.

At one time I had charge of a small ice plant at the Rice Indian School, Talklai, Ariz., making ice from spring water which, coming through granites, was relatively soft. We had no condenser and no air agitation, the ice coming in what is usually termed "snow balls." As we had fifty weeks of hot weather each year, we were not hypercritical, but when the ice house was full, I did a little experimenting. By passing the water through the fore cooler slowly, and carrying the brine at 28 deg. I would get relatively clear ice for a few inches around the sides of the can. The core would be unusually thick and white, unless I withdrew the water twice, in which case the ice looked like ordinary can ice made from distilled water. This is substantially what happens when the water in a lake or river freezes.

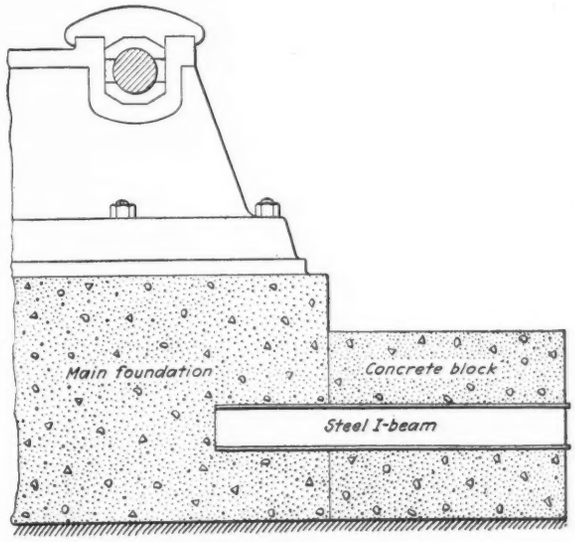
That air agitation enables one to use unsanitary water or methods would be an excellent argument against it, but I do not think that its proponents would use it. Air agitation was brought out to enable the ice maker to produce ice of a quality of the plate plant with the commercial advantages of the can plant, and it does when properly handled. There is one objection: Any impurities in the water will be concentrated in the center, and if not withdrawn, either through carelessness or neglect, will reappear in the core. Much depends on the interpretation of the expression "properly filtered." A sand filter will remove practically all the bacteria in impure water in this way: At first the bacteria pass through, but soon stop and colonize, so that an old bed is a hotbed of germs, even though the water delivered is pure. This was proved in Germany, at Altona, when an epidemic raged at Hamburg. The former drew its water from the Elbe and passed it through sand filters, and did not have a case.

As to ice cubes from domestic refrigerators, in cities with water as soft as New York, the Great Lakes, Mississippi River, etc., if the consumer will boil the water, cool and pour into his pans without any unnecessary agitation, he will get comparatively clear ice. A fifteen-pound cylinder of liquid carbon dioxide is an excellent substitute for chilling water, etc., but lacks the clinking sound in a glass. L. R. BAKER.

Cleveland, Ohio.

Stabilizing an Engine Foundation

A SLOW-SPEED GAS ENGINE of fairly large size had been mounted on a concrete foundation built upon unstable ground. The engine had not been long in service when the foundation began to rock. Since no means could be devised for giving the foundation block a firmer anchorage in the soft ground, it was decided that the only solution was to increase its static inertia. It was figured



Stabilizing engine foundation by adding weight

that if the foundation's center of gravity were shifted to a point nearly beneath the axis of the crankshaft the rocking tendency would be diminished or abated altogether. How this was done is illustrated in the accompanying sketch.

The procedure was first to drill and chip two rectangular holes in the front end of the foundation block, each to a depth of about 20 in. and at a distance from the vertical edge of the block equal to an eighth of its width. Heavy steel I-beams 5 ft. long were inserted in these holes and a grouting of rich gravel concrete was blown in around them.

Two masses of concrete to hang on the projecting ends of the steel beams were then poured in wooden forms, a rectangular duct of wood being fastened in each form in the proper position for coring out the necessary holes. A rich mixture of concrete was tamped into the forms and given plenty of time to harden. When the inclosing timbers were knocked away and the core ducts splintered out, two compact monoliths of concrete, each weighing about 2½ tons, stood exposed. By means of a tackle suspended from a tripod erected over the engine, these blocks of concrete were slipped along the protruding girders to contact with the main foundation structure. Cement grouting was then blown in to fill the indentations in the abutting surfaces, which previously had been well nicked and roughened with a steel pick.

It was found that the additional weight of approximately five tons removed all tendency of the foundation to rock. The improvement was worked out at considerably lower cost than any attempt at strutting or solidifying the ground under the structure would have entailed, had such a plan been feasible.

St. Louis, Mo. A. J. Dixon.

Reducing Power Consumption of Magnetic Contactor Coils

We have two automatic railway substations using magnetic contactors for starting and running the rotary convertors. At one of these stations the contactors are of a heavy design, controlling a 3-phase circuit of 445 volts rated about 400 amperes.

The operating coil was designed for 220-volt operation, but actually operates at 230 to 240 volts, due to high primary voltage. The "running" contactor coil has always run a high operating temperature, and the manufacturer was notified of this soon after the installation was put into operation. We were assured that the coil was designed for and could be expected to reach operating temperatures equal to an ordinary smoothing iron.

However, we replaced the original "running coil" with a spare after about six months' operation; it was badly baked out. The spare coil lasted about eight months and "blew up." We put the original coil back on and ordered two more, as this happened in mid-winter with our load at its peak and we could ill afford to have the machine off. The old coil lasted two days. After waiting three days for the new one we decided to make one.

The old unit was too badly burned to count the turns or use the old form, which was of a special shape; so we made a new form of ⅛ in. red fiber. The wire was weighed (No. 8) and exactly the same weight in No. 9 was bought to rewind with. The idea was to get about a hundred more turns in the same space, to reduce the excessive heating and current.

When installed the contactor closed perfectly; one man could not pull the armature back, so we thought it was good enough. On a load comparison we found that the old type coil drew 16¾ amp. and the rewound job 6½ amp., representing a clear saving in station power of over 2 kw. per hour in operation.

Under continuous load the armature reaches a temperature uncomfortable to the hand, but the coil does not show the extreme heat and baked appearance as before. It has operated for six months and looks good for as many years. The two new coils were delivered from the factory in six weeks. They are still in stock as spares.

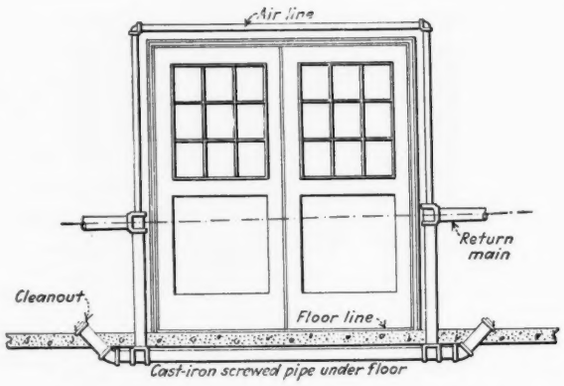
We did not equip the starting contactor with a low current coil, because it draws current through the starting period only, about 30 to 40 sec., and not over two minutes in abnormal operating conditions.

Nashville, Tenn. Thomas E. Miller.

Providing for Free Flow of Air in Heating Return Lines

Where a return line from a heating system supported on a wall passes across a doorway or other obstruction where a clear passage is desired, a full-sized line for carrying the condensate is run under and a smaller line to allow for the passage of the air is run over, as shown in the sketch.

If no air line were installed, the line under the doorway would obstruct the air by forming a water seal. This water could only be removed by a vacuum pump, with



Changes made in return line to pass obstruction

which all systems are not equipped, and would fill again as soon as the pump was idle. By keeping the discharge side the same level or lower the entire system is drained free of water irrespective of any vacuum pump.

As this line catches all heavy particles carried along in the condensate, such as scale, etc., it is necessary to provide clean-outs. Steel or wrought-iron pipe will not last long buried in the ground with damp earth in direct contact; cast-iron or brass pipe are better and will cost less than a trench and cover.

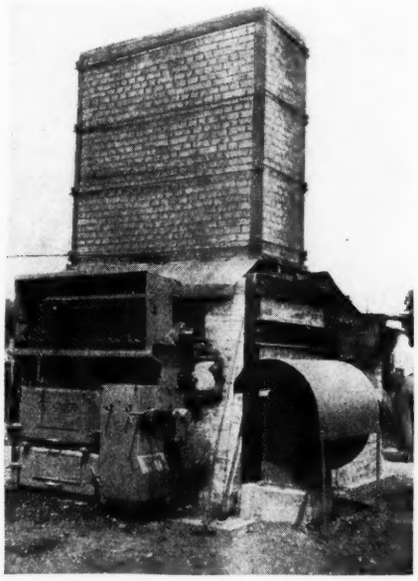
Remember to provide for expansion. This is taken care of by wrapping the pipe in building paper and aircell covering where it passes through the floor slab.

Portland, Ore. Jay H. Keller.

Developing a Furnace to Burn Anthracite Buckwheat

THE accompanying illustration shows a special furnace erected at the plant of the Whiting Corporation in Harvey, Ill., for the purpose of developing the proper shape, and proportion of arches for the burning of anthracite buckwheat. There is simply a furnace and short stack equipped with a Whiting stoker and a motor-driven fan to produce the draft for combustion. No boiler was provided, as the intention is to demonstrate the performance of the furnace with anthracite and other coals. Both furnace and stoker were designed by Joseph Harrington, president of the Whiting subsidiary, the Joseph Harrington Company.

During an interval following several successful tests with anthracite, and while awaiting the arrival of more coal of this character, arrangements were made with the Illinois Coal Bureau for a truck load of standard Franklin County screenings. On June 22 this coal was burned in the presence of thirty interested spectators representing various coal-producing companies of Illinois and including consulting engineers and representatives of several large coal-using industries.



Special furnace designed to test the burning of anthracite buckwheat

While the furnace is designed primarily for anthracite, it also will burn bituminous coal with no changes in the design. It is bottled up more than is necessary for high-volatile coals and has a long reversed arch which extends forward from the bridge wall and slopes upward in such a way as to compel the hot gases from the incandescent portion of the fire to sweep forward and over to come in contact with the incoming fuel, and especially to impinge on the curved-front ignition arch. The impingement of these gases on this arch and upon the upper surface of the fuel beats both to a point where ignition promptly takes place.

It was demonstrated that the stoker could handle bituminous screenings from Southern Illinois at high rates of combustion without the production of smoke and with no clinker formation either on the sides of the furnace, on the grate surface, or in the ashpit. By weight, 1,288 lb. of coal per hour were fed onto a grate 5 ft. wide and 7 ft. long, which is at the rate of 36.8 lb. per square foot per hour.

Owing to its construction the furnace has a volume of only 125 cu.ft., including the space to the top of the stack. The flame extended some 5 or 6 ft. above the stack, and, strictly speaking, the volume should extend to the end of the flame. Without taking this added volume into account, the heat release per cubic foot of furnace per hour figured 124,400 B.t.u., and probably about 100,000 B.t.u. when considering it.

The color of the flame was dazzling white, and the temperature undoubtedly ran up to 2,600 to 2,700 deg. F. Under other circumstances such a temperature would melt the ash to a liquid. In this case there was no sign of clinker formation. The ash came over into the pit well burned out and entirely soft and loose.

Lack of impingement on the side walls may be explained by the fact that these walls were set back about 6 in. from the edge of the grate surface, where the blast approaches most closely to them. While the side walls were white hot, there was no clinker accretion, as the fuel did not come in contact with them. The rate of combustion indicated was secured with an average draft pressure under the grate of about 0.7 inches.

▼ ▼ ▼

Operating Experience With Supervisory Automatic Control

A PAPER, "Three Years' Operating Experience With Miniature Switchboard Supervisory Automatic Control," presented at the summer convention of the American Institute of Electrical Engineers, R. M. Stanley, electrical engineer, Byllesby Engineering & Management Corporation, gave the results of the three years' operating experience at the Falls of the Ohio hydro-electric station at Louisville, Ky. This plant contains 8 units, each rated at 13,500 hp. under a 37-ft. head. The hydraulic control unit and an automatic electrical control unit are near each generator. The electrical control equipment is similar to that used in all stations, but is placed inside a steel cubicle adjacent to the governor. A centralized supervisory control miniature switchboard, to which the generator control units connect, is located in about the center of the plant.

Engineering reasons for adoption of miniature supervisory switchboard control and automatic control were to reduce initial capital expenditure and lower fixed charges. The results of more than three years' continuous operation of this equipment show the following:

With the miniature switchboard, the operator is at all times closer to indicating instruments, control switches, etc., and can give better and closer supervision, to the operation of the equipment, resulting in better voltage control, frequency control, and division of load among generating units.

There is a great saving in time during regular operation and human error is largely eliminated.

There is a marked saving in labor costs, since there is only one shift operator required to operate the entire station.

Maintenance on the miniature supervisory board is no greater than on vertical boards of older types and, as far as comparisons can be made, appears to be less. Very little trouble has been experienced, apparently slightly less trouble than on older types of boards, although this installation was one of the first used in a large generating station. During system disturbances the operation of the miniature switchboard, as compared with a modern switchboard of standard power house type, now in service at the Waterside steam station, of 92,000-kw. capacity, indicates that the miniature supervisory board is more convenient, saves time, reduces chances for error, and results in quicker restoration of service.

The use of automatic devices controlling the electrical equipment, waterwheel governor, oil pressure, bearing-water pressure, etc., has demonstrated its reliability, low cost of maintenance and inspection, saving of time, saving of operating expense, and better and safer supervision and operation of electrical equipment than would be possible by manual system of control.

This operating experience indicates that hydro plants or steam generating stations can be supervised from miniature switchboards with, or without, automatic features. It is believed that, in hydro plants where units are taken off and put on the bus regularly and frequently, this type of control equipment is not only superior to manually operated equipment but the plant will be operated with greater safety to equipment.

From Among Readers' Problems

Conducted by
L. H. MORRISON

SIZE OF STEAM LINE—*We recently obtained a second-hand, 100-hp., non-condensing steam engine for installation in our plant. It will be supplied with dry steam at 120 lb. pressure and under our operating conditions we expect a steam rate of about 40 lb. per horsepower hour. What size steam line should we run to this engine?* G.M.S.

For such installations it is good practice to select a pipe size that will limit the steam velocity to about 4,000 ft. per minute. The pounds of steam passing to the engine will be $(100 \times 40) \div 60 = 66.6$ lb. per minute. Dry steam at 120 lb. gage pressure has a specific volume of 3.33 cu.ft. per pound. The steam pipe to the engine must then pass $66.6 \times 3.33 = 221.8$ cu.ft. of steam per minute. For a velocity of 4,000 ft. per minute the pipe cross-section must be not less than $221.8 \div 4{,}000 = .055$ sq.ft., or 7.92 sq.in. With 120 lb. steam standard weight pipe can be used, and the nominal pipe size with a cross-section not less than 7.92 sq.in. is $3\frac{1}{2}$ inch.

BOILING OUT A BOILER—*How is simmering or boiling out of a horizontal return-tubular boiler performed for the purpose of cleaning it of grease and scale?* P.C.K.

Boiling out usually is performed after the boiler has been blown off and washed as clean as possible with a hose. The boiler is then filled with clean water to a point higher than the upper limit of oil or scale deposit and a liberal amount of soda ash is added. The quantity depends upon the size of the boiler. For a 72-in. horizontal return-tubular boiler use about 40 lb. The efficiency of the soda ash is increased by the addition of about one-tenth of its weight of caustic soda. The soda ash and caustic soda should be dissolved before being put into the boiler.

When the change of soda solution has been added a slow fire should be built in the furnace and maintained for two or three days with regulation of the heat so the water will be kept boiling gently. Leave the manhole or other openings uncovered so that no pressure will accumulate. When the boiler has been "boiled out," washed and ventilated, the scale that has been loosened should be removed and the boiler cleaned with hand tools or mechanical cleaners, as soon as possible, so that the scale that has remained attached will have little time to become harder from drying.

OVERHEATING OF AIR COMPRESSOR—*We have a 5½x5-in. motor-driven air compressor. The air cylinder becomes so hot as to cause paint or oil on the outside to smoke. What is the most likely cause of this overheating?* P.S.C.

Overheating of the air cylinder of an air compressor might result from burning of the cylinder lubricating oil if the oil has too low a flash point, or from having insufficient circulation of cooling water of low temperature. Excessive heating also may result from leakage of the discharge valves. The air attains higher temperature from compression. And when the discharge valves leak, part of the heated compressed air, instead of being delivered to the receiver, finds its way back into the cylinder and is recompressed along with the free air taken in for compression, thus building up a higher cylinder temperature.

CLATTERING NOISE IN ENGINE AT LIGHT LOAD—*During part of each day our 24x48 non-condensing corliss engine must run with a very light load and at such times there is a bad clattering in the cylinder. How can this be prevented?* B.C.D.

Operation of the engine should be studied from indicator diagrams taken under different load conditions. The noise with the light load probably arises from cutting off so short that expansion goes below atmospheric pressure. Trouble from this cause may be prevented by sufficiently throttling the admission pressure to obtain a later cutoff. It the desired result cannot be obtained in that manner, then at a small expense of economy the terminal pressure can be prevented from going too low by connecting together the indicator connections at opposite ends of the cylinder with a stop valve between them, leaving the valve open no more than is necessary to stop the clattering of the engine valves, or by leaving the cylinder cocks open a little to the atmosphere.

PREVIOUS QUESTION
DISCUSSED BY READERS

THE QUESTION

WE HAVE A 1,800-r.p.m., 125-g.p.m., multi-stage centrifugal boiler-feed pump in our plant and I am told that unless there is absolutely full opening in the discharge line the pump will have a tendency to lose the balance thrust and thus ruin the impellers. My contention is that as long as there is any circulation of water through the pump, even if the flow is restricted, the pump will operate without danger. We are at present operating as a stand-by station and use approximately 70,000 lb. of steam per 24 hr. The steam demand is fairly constant. Can this pump be operated by throttling the discharge without danger of ruining it? E.S.Y.

THE PROBLEM is best broken into two considerations. The first is that of pump rating and capacity. As the delivery of 70,000 lb. of steam per day is at a fairly constant rate, this can, for our purpose, be reduced to a rate of 5.86 g.p.m., which is but 4.6 per cent of the pumps capacity. So small a flow should be handled by a small reciprocating pump, as no centrifugal pumps are made to handle such low ratings.

The second consideration is that of operating the present pump. Reducing the output on a centrifugal pump results in a higher discharge pressure, this being an inherent characteristic of most boiler-feed pumps. As the discharge pressure increases, the wear on the initially small clearance between the casing and the balancing drum increases the clearance, allowing a greater leakage to flow from the discharge end of the pump to the low-pressure side of the balancing drum, this leakage being handled by a pipe or space in the pump casing so as to be returned to the suction end of the pump. As the leakage increases due to pressure differential and erosion of the clearance, the efficiency of the pump is rapidly reduced.

In short, the cost of operation due both to maintenance and loss in efficiency should point toward the use of a small piston pump.

Springfield, Ill. S. G. MILLARD.

A MULTI-STAGE centrifugal pump will operate without danger at any flow up to its capacity so long as that flow is sufficient to take away the heat developed by the rotor in creating pressure. At small flows this rotor action results in excessive churning, and if the flow were totally cut off the water would rapidly become so hot that the pump bearings would seize.

We operate two 1,800-r.p.m., 80-g.p.m., 3-stage centrifugal pumps alternately to feed an 8,000-kw. electric steam generator, the feed being controlled by a hand-operated angle valve in series with a check valve. These pumps are motor-driven and run full speed at all times, while the boiler load supplied varies from 125 b.hp. in summer to 1,000 b.hp. in winter. The rotors of these pumps are in perfect condition after four years' service. By allowing a small amount of water to escape by the shaft packing we have succeeded in doing away with any trouble from heating at that place.

Arvida, Canada. M. G. SAUNDERS.

MULTI-STAGE boiler-feed pumps may be of either single-suction or double-suction runners.

In the double-suction type each stage is balanced by the water entering the runners at both sides at the shaft and discharging at the periphery, the same as in a single-runner double-suction pump. Therefore there will be no unbalance under any operating condition.

In the single-suction type of multi-stage pump, there is unbalance due to the difference in pressure that exists at the two ends of the pumps, these pressures being the suction pressure of the first runner and the discharge pressure of the last runner. A balancing device is therefore necessary. The simplest and most common type consists of a plate mounted on the shaft, so arranged that the pressure of the last stage acts on one side of it in the opposite direction to the unbalance caused by the runners. The water that escapes around the edges of the plate is piped to the suction end of the pump, which leaves a low pressure on one side and the discharge pressure on the other side of the plate. It is therefore only necessary to arrange the area of the plate to correct the unbalance of the runners, and as the unbalance is due to pressures only, the balance plate will correct it under all conditions of operation.

Vancouver, B. C. R. E. POTTER.

ONE OF THE chief advantages of centrifugal pumps over reciprocating pumps is that the former can be operated at constant speed and varying output, it being thus well adapted to direct connection to high-speed motors, engines or turbines. The only way to decrease the output of such a pump at constant speed is to increase the total head. It does not matter whether the increase in head is due to an increase in the actual lift of the pump, as when filling an overhead tank, or to an increase in friction brought about by partly or fully closing one or more of the valves through which the pump is discharging. Likewise, the discharge of the pump may be increased by allowing it to operate at a reduced total head obtained either by lowering the static head or by reducing friction by opening wider the discharge valve.

Since the ability to operate at varying heads is one of the fundamental characteristics of centrifugal pumps, and since changing the position of the discharge valve is a very convenient way of controlling the head, we might say that this is the normal way of controlling the output of this type of pump. Any such pump, therefore, which gives trouble when the discharge valve is partly closed is not operating normally.

Cases of unequal thrust in such pumps have been known to exist, but are invariably found to be due to such causes as plugged balancing orifices, clogged impellers or worn parts within the pump itself. Such defects, however, usually give more or less trouble at all pump ratings, as manifested by a tendency to vibrate, heat up the thrust bearings, etc. Such troubles may be remedied by removal of the defect.

Assuming that the pump in question is in good condition, I suggest that it be operated with the discharge valve throttled to any extent that may be necessary to secure the desired output. The existence of a greatly uneven thrust for any discharge valve position indicates some abnormal condition within the pump, the cause of which should be determined and removed at the first opportunity. M. F. KNOY.

Beaumont, Texas.

A Question for Our Readers

TO IMPROVE the economy of our boiler room we are installing economizers that are designed to reduce the flue gas temperature from 600 to 350 deg. The economizer is guaranteed to have a draft loss of not over 1 in. at maximum rating. Assuming the same rate of combustion, will our old induced draft fan have sufficient capacity to handle the cooler flue gas and increased resistance? The fan has a capacity of 50,000 c.f.m. at 600 deg., 3 in. pressure and 600 r.p.m. It is driven by a 40-hp. direct-current motor. What changes to motor are necessary?

Suitable answers from readers will be paid for[1] and published in the Sept. 1 number

IT IS MY OPINION that the author of this question is correct in his contention and that someone has given him misleading instructions.

Other things being equal, the pressure on the discharge of a centrifugal pump depends upon the conditions in the discharge line. If a valve in the line is partly closed, the pressure will rise; if the valve is opened the pressure will drop.

Let us suppose that the pump is operating without a discharge valve or with the valve opened wide. Now, with the pump running steady, the pressure regulation on the discharge of the pump will be taken care of by the feed-water regulating valve on the boiler. It is not at all unreasonable to assume that with a very steady flow of steam from the boiler the regulator valve could assume a fixed position that would hold the feed-water pressure constant. It is understood that such conditions as these would not be harmful to the feed pump, since such conditions are duplicated in countless plants every day, at least for some interval of time.

If there were no feed-water regulator valve in the line and all of the regulation was done by pinching back on the discharge valve at the pump, the same conditions would be established, except for the fact that the regulation would be nearer the pump.

I cannot see how the location of the regulating valve in the discharge line should affect the action of the pump.

I have assumed that a standard design of pump with the usual pumping characteristics is being used. A pump of freakish design, balanced at one definite pressure only, would probably cause some trouble if the pressure were to be varied.

The pump can be operated with the discharge valve pinched back if necessary, so long as enough water is passing through the pump to prevent overheating. Such a small amount of water is required for this purpose that one would be safe in saying that the pump is in no danger so long as it is pumping any quantity of water. R. F. SORRELLS.

Beaumont, Texas.

[1] As an alternative to cash payment for answers published, readers may select any one of the following books. (Be sure to state the book desired):

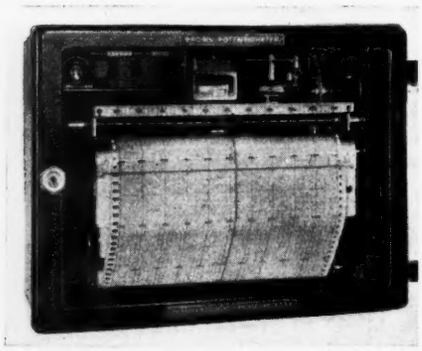
Morrison's *American Diesel Engines;* Walker and Crocker's *Piping Handbook;* Norris and Therkeisen's *Heat Power;* Emswiler's *Thermodynamics;* Church's *Steam Turbines;* Uehling's *Heat Loss Analysis;* Croft's *Steam Power Plant Auxiliaries and Accessories;* Powell's *Boiler Feed Water Purification;* Osborne's *Power Plant Lubrication;* Moyer and Fritz' *Refrigeration;* Rietschel-Brabbee's *Heating and Ventilation;* Annett's *Electric Elevators.*

WHAT'S NEW IN PLANT EQUIPMENT

Improved Potentiometer Pyrometer

A NEW potentiometer pyrometer in indicating, recording, multiple recording, and controlling types has been developed by the Brown Instrument Company, Philadelphia, Pa. The new intrument is a Null-type potentiometer in which a galvanometer directs the operation of the mechanism to rebalance the circuit for each change in electro-motive force that is measured.

The galvanometer is designed to have a uniformly high responsiveness under



Brown potentiometer pyrometer

all practical operating conditions. The balancing mechanism exerts no strain upon the galvanometer pointer, and the mechanical movements of the secondary pointer are comparatively large. The charts and scales are made to conform to the latest calibration values for Iron-Constantan, Chromel-Alumel, and Platinum-Rhodium thermocouples. To eliminate errors caused by the natural expansion and contraction of the chart paper that takes place with changes in atmospheric humidity, a humidity compensator is built into the instrument and automatically corrects the pen position and brings it into proper register with respect to the chart markings.

The dustproof case of the instrument is equally suitable for wall, front-of-board, flush-type panel or table mounting. The case is entirely inclosed, and there are no openings through which the chart must extend. A re-roll attachment for the chart is standard and can be used if preferred, or the chart may be allowed to accumulate in the bottom of the case.

Automatic control is obtained through mercury switches which can handle up to 50 amp. at 220 volts (60 amp. at 110 volts). The instrument may be provided with as many as three mercury switches, making it applicable to the operation of various valve-control mechanisms or signal lights.

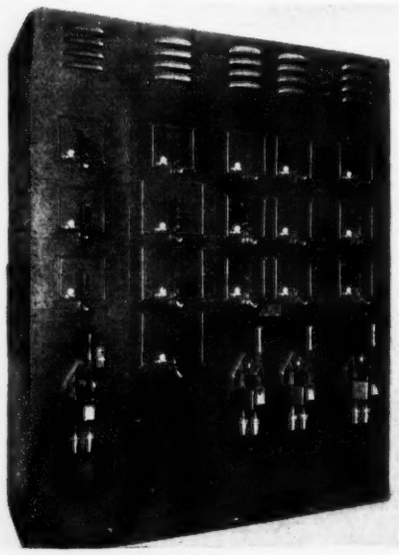
Multiple recorders employ the color code, and a new "balanced stroke" feature causes the record to be printed and the instrument connected to another thermocouple as soon as the proper balance adjustment has been reached. This results in more frequent printing and consequently more accurate and legible multiple records.

Dead-Front Steel Inclosed Switchboard

THE "SAFtoSWITCH-BOARD" illustrated is a dead-front totally steel-inclosed switchboard and consists of an assembly of standardized sectional panels, all parts of which, such as steel frames, steel inclosures and ball-bearing switches, are also of standardized unit construction.

The switches incorporated in the board have ball bearing guides, which permits full floating positive contact and insures simultaneous double break. The switch is a self-contained unit of compact design, embodying separate fuse and switch compartments interlocked for safety in replacing fuses. The standardization of these boards provides for the interchangeable mounting of the ball-bearing switches for all polarities, capacities and voltages.

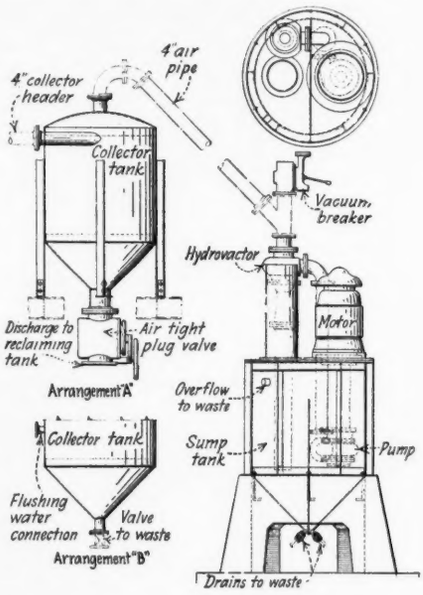
The board is put out by The Bull Dog Electric Products Company, 7610 Jos. Campau Ave., Detroit, Mich.



Board assembled from standardized sectional panels

Hydrovacuum Unit for Handling Soot, Siftings and Other Materials

ALTHOUGH DESIGNED primarily for handling soot, siftings and floor sweepings in power plants, the hydrovacuum unit put out by the Allen Sherman Hoff Company, 219 South 15th St., Phila-



Two arrangements of hydrovacuum system

delphia, Pa., can be adapted to handle various other materials.

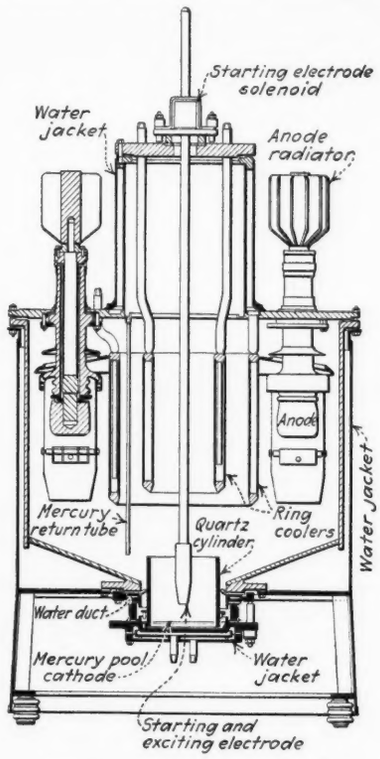
The unit consists of a "hydroseal" pump which delivers water at high pressure through a hydrovactor and discharges through a nozzle ring, creating a high vacuum. The water discharges into a sump tank and is recirculated. The vacuum side of the hydrovactor is connected to the collector tank, into which the soot or other material is drawn in a dry condition. The unit is designed to handle between 10 and 15 tons of fine material an hour through a 4-in. header, and the material may be discharged dry as shown in arrangement *A* or wet as in *B*.

The unit can be applied to soot handling by the application of standard A-S-H wind-swept valves beneath the soot-collection hoppers. For handling siftings, wind-swept valves are used beneath the siftings hopper and cyclone collector tank. The siftings may be returned to the boiler to be burned or to

other points of disposal. To adapt the unit to cleaning plant floors and equipment, vacuum cleaner nozzles are applied. The hydrovactor and wind-swept valves previously referred to were illustrated and described in the Sept. 16, 1930, number, and the hydroseal pump in the May 5, 1931, number of *Power*.

Steel Tank Mercury-Arc Rectifier

THE steel tank mercury-arc rectifier, which converts alternating to direct current over wide ranges of both voltage and current, is announced by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Although the most general use of this equipment is in supplying power for electric traction systems, it has certain industrial applications. For some electro-chemical processes the power supply

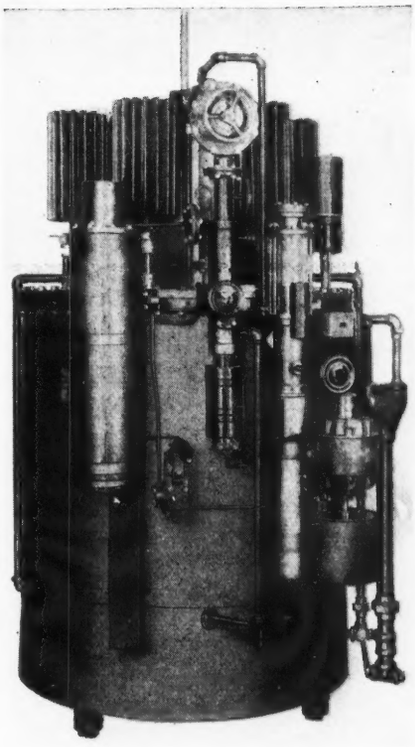


Cross-section of rectifier unit

quirements are such that rectifiers provide the preferable means of conversion.

Operation is based on the principle that in an ionized gas only a small positive potential, with respect to the gas, is required to cause current to flow to an electrode, while a large negative potential can be applied before appreciable current flows. The rectifier consists of a mercury pool cathode and an anode inside a steel tank, with facilities for condensing the mercury vapor, and the necessary auxiliary apparatus for maintaining the vacuum and temperature conditions of the rectifier within the limits required for proper operation.

The mercury pool is contained in a cathode plate or disk insulated from the tank by a porcelain ring, the construction providing a cathode assembly re-



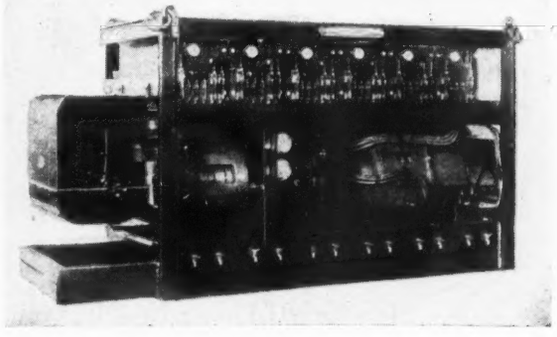
Mercury arc rectifier of 500-kw. capacity

movable as a complete unit. The anodes are of graphite. The starting electrode is a steel rod, which is drawn down to make contact with the surface of the mercury pool by a solenoid coil. The contact between the starting electrode and the pool short circuits the coil and the electrode is withdrawn from contact, causing an arc.

Switching equipment is available to meet the various applications ranging from manual to full automatic control. A 500-kw. unit is illustrated.

Constant-Potential Multple-Arc Welder

CONSTANT-POTENTIAL, multiple-arc welders with capacities ranging from 400 to 1,500 amp. (one-hour ratings), have been developed by the Wilson Welder & Metals Company, Inc., North Bergen, N. J. All of these machines are four-bearing, single motor-generator types, and all have close control. Panels are mounted either on the frame of the motor-generator set or separately in any part of the plant.



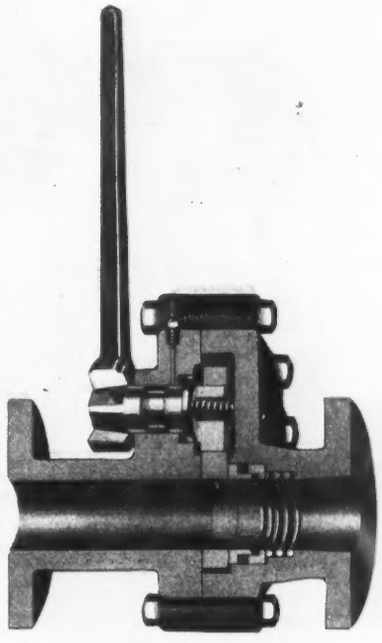
Wilson constant-potential multiple arc welder, which is built in one-hour ratings of 400 to 1,500 amp.

Lever-Operated Valve for Industrial Processes

QUICK OPENING and free flow features are incorporated in a line of lever-operated swing-gate valves "Pretite," manufactured by the Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pa.

The valve is fitted with a one-piece solid disk with a seating surface on both sides. The disk is in contact with its two seats during the opening and closing cycle, a seating bushing, spring-packed, being used on the inlet side as shown. With the valve in the open position a straight-through passage is provided, with all the seating surfaces protected.

The valve is especially suitable for use in the chemical, paper, rubber and other industrial process systems, and is made in the following metals: iron, steel, stainless steel, acid bronze, aluminum and special metals. Sizes range from ½ to 4 inches.



Section through lever-operated valve

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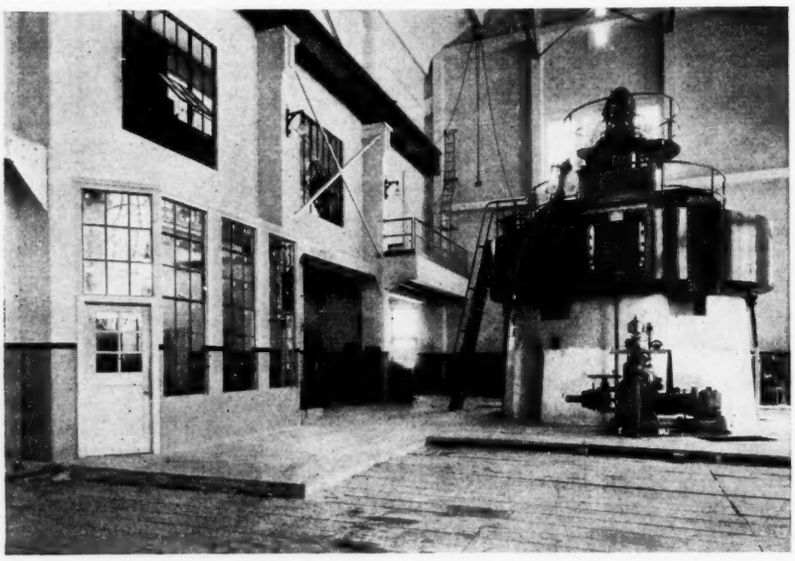
IN THE description of the "Coal Spreader and Gasifier," in the July 7 number, the address of the manufacturer, the Gebhardt Company, Inc., was inadvertently given as 543 instead of 343 South Dearborn St., Chicago, Ill.

NEWS of the FIELD

Mokelumne River Hydro-Electric Development Placed in Operation by P. G. & E. Company



Interior of Salt Springs power house showing initial unit, a 14,500-hp. Francis-type Pelton turbine driving a Westinghouse generator

FIRST UNITS of the Pacific Gas & Electric Company's $40,000,000 hydro-electric development on the Mokelumne River, Calif., have just been placed in service. Adding 94,500 hp. to the company's generating facilities, the first stage of the project includes the completion of Salt Springs Dam, the largest rock-fill dam in the world; an initial installation of one 14,500-hp. unit in the Salt Springs power house; completion of the Tiger Creek power house with a capacity of 80,000 hp.; completion of the Salt Springs-Tiger Creek conduit, an 18-mile concrete flume, 14 ft. wide and 7 ft. deep; 110 miles of 220,000-volt transmission line from the Mokelumne plants to the Newark substation, which has been enlarged to triple its former capacity.

Completion of the project involves the construction of a second dam on the Bear River, which will create a reservoir with a capacity of 34,000 acre-ft. and a static head of 2,104 ft. When this is finished a single overhung horizontal impulse unit of 33,500 hp. will be added to the Salt Springs power house. Twenty more miles of conduit will be constructed, along with a 20,000-hp. generating plant at West Point. The present Electra power house will be reconstructed and its capacity raised from 26,000 to 80,000 hp. With these facilities added to the already completed units, the Mokelumne development will reach its ultimate designed capacity of 228,000 horsepower.

Program Announced for Smaller Industries Meeting

TENTATIVE PROGRAM has just been announced for the First Conference on Management Problems of the Smaller Industries, which will be held at Silver Bay on Lake George, N. Y., from Aug. 10 to 15. The conference will open with an afternoon session on Monday, Aug. 10, and thereafter regular business sessions will be held in the morning and evening, leaving the afternoons free for recreation.

The subjects to be covered include the status and economics of small plants, planning and scientific management applications, personnel and safety problems, sales and development. Among the addresses which will be given are: "The Small Plant's Place in American Industry—Its Problems and Its Opportunities," Burnham Finney; "The Small Plant's Responsibility in Economic and Social Progress," Charles Nagel; "The Trade Association and the Smaller Manufacturer," P. P. Gott; "What Industrial Management Has Learned From the Last Two Years," Ralph E. Flanders; "The Possibilities of Planning and Budgeting in the Smaller Plant," C. A. White; "How Can the Manager of a Small Plant Discover in Advance the Extent to Which It Is Profitable to Be Scientific," Arthur Scott; "Motion Study Applied to Small Plant Operation," A. H. Mogensen; "Is a Research Department Practicable in a Small Plant?" W. D. Harvey; "The Power Problem of the Smaller Plant," E. C. Hutchinson; "Standard Costs for Small Manufacturing Plants," J. P. Jordan.

Seek New Utility Tax and Commission in Georgia

BILLS were introduced July 21 in the Georgia House of Representatives to impose a tax on the gross receipts of public utilities and to abolish the present Public Service Commission and create in its place a Commerce and Utility Commission.

The taxation bill, introduced by Representative Stewart, provides for an annual tax of $2 on each $100 of gross receipts from intrastate business of electric, gas and communication companies.

The other measure was introduced by Representatives Lester, Lanier and Cartledge. It would provide for a new commission of three members to be chosen by the Legislature instead of the existing elected commission of five.

Establish Fellowship for Boiler Feedwater Study

A NEW FELLOWSHIP at the Ohio State University has been established by the Joint Research Committee on Boiler Feedwater Studies sponsored by the American Railway Engineering Association, the American Society of Mechanical Engineers, the American Society for Testing Materials, the American Water Works Association, the American Boiler Manufacturers Association, and the National Electric Light Association.

Under this agreement the committee is to award the university $1,000, to

establish a special fellowship in boiler feedwater investigation with a stipend of $750 to be paid in nine equal installments; the other $250 to be used for equipment which will become the property of the university at the completion of the investigation.

Solomon F. Whirl has been appointed to the fellowship. The whole investigation is under the direction of Professor C. W. Foulk of the department of chemistry, and is a part of the work of the Engineering Experiment Station Project No. 103.

State Can Regulate Rates of City Plant, Court Decides

DECLARING that the state has the power to regulate the rates charged by municipally owned public utilities, the Indiana Supreme Court has decided against the City of Logansport in its suit to set aside an order of the Indiana Public Service Commission, which reduced its rates for electric service. The city contended that it was vested with the right to fix the rates charged by virtue of its inherent power as an independent body politic and that such rates could not be regulated by a commission of the State Legislature. It also contended that the rates fixed by the commission were inadequate and confiscatory.

In rendering the decision, the court stated that a municipal corporation possesses two capacities, one governmental and the other private, and that "a city in the operation of an electric light utility, selling service to the public, acts in its private business capacity and not in its public governmental capacity" and is therefore "subject to the same liabilities, limitations and regulation as any other public utility."

The court further stated, "The regulation of rates to be charged by public utilities is properly the function of the legislative department of the state government, under its police power," and that "even under the power to exercise self-government or home rule, a city cannot act on matters of purely state concern"; furthermore, "a municipality has no inherent rate making power and in the absence of constitutional or statutory authorization cannot regulate utility rates. The power to fix rates may be and has often been delegated by the state to municipal corporations, but authority so given is subject to legislative control and when the legislature delegates to the Public Service Commission the exclusive power to regulate rates, that grant supersedes any grant heretofore made to cities."

Two Industrial Plants Remodeled to Burn Gas

TWO POWER PLANTS serving industrial and mining operations in the Southwest have recently been remodeled to burn natural gas as well as fuel oil. In one of these at Trona, Calif., fifteen Peabody combined oil and gas burners were installed to fire two 14,000-sq.ft. boilers, having a maximum equivalent evaporation of 193,000 lb. of steam per hour. This plant supplies steam for the operations of the American Potash & Chemical Company and is located in the famous Death Valley of California, some 270 ft. below sea level.

The other plant, which serves the Calumet & Arizona Mining Company at Lowell, Ariz., has just gone back into operation, equipped to burn natural gas as the principal fuel with oil as a standby. Previously, oil only was used at this plant, but it was decided to change to natural gas, and the Peabody combined burners were installed to fire two 7,250-sq.ft. boilers.

News of Canada

Beauharnois inquiry proceeds with revelations of contributions to political parties and huge profits made

THE BEAUHARNOIS INQUIRY continues to occupy the center of the political spotlight in Canada in view of recent startling disclosures and developments. On July 17, it was revealed that approximately $1,000,000 had been contributed to political campaign funds by the Beauharnois company and its president, R. O. Sweezey.

As nonchalantly as a man revealing his golf score, Mr. Sweezey told the committee that contributions totalling about $954,000 had been made to federal political parties and to the campaign funds of the Liberal and Conservative parties in Ontario and Quebec. Between $700,000 and $800,000 had been contributed to the federal Liberal party and the Liberal party in Quebec. This was given to Senators Haydon and Raymond upon the understanding that an undefined percentage was to be delivered to the Quebec provincial Liberal party. The Liberal party in Ontario had received "trifling sums" somewhere in the neighborhood of $3,000. A further $200,000 had been offered to the federal Conservative party prior to the last general election but had been declined by R. B. Bennett, then leader of the Opposition in Parliament and now Premier.

Another outstanding development of the last week was the refusal of Senator W. L. McDougald, chairman of the board of directors of the Beauharnois Light, Heat & Power Company, to appear for examination, on the ground that the committee had no authority to

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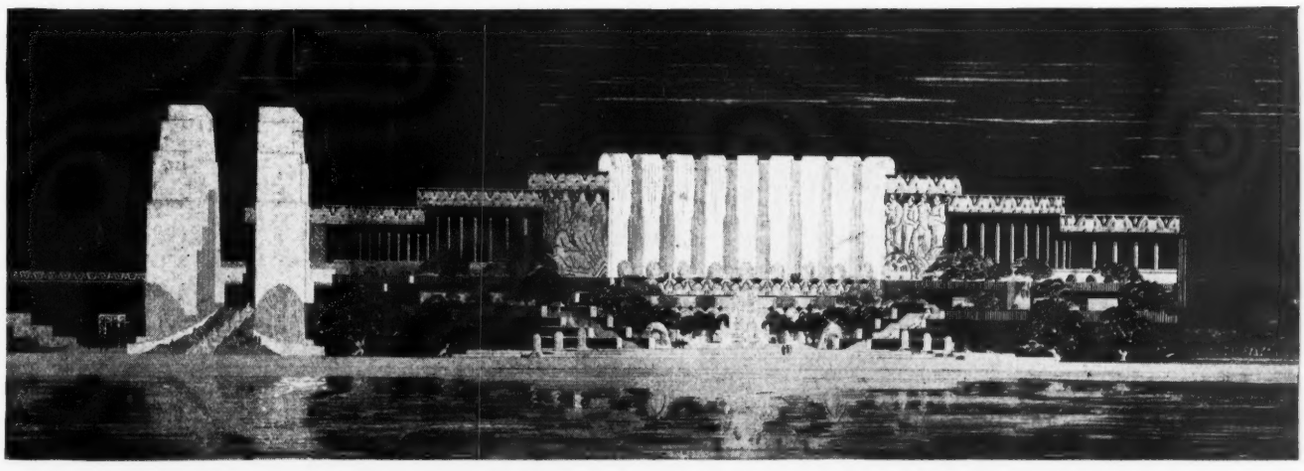
START CONSTRUCTION OF POWER BUILDING FOR 1933 WORLD'S FAIR



Ground was broken on July 20, for the Electrical Group, designed by Raymond Hood of New York, and the fifth structure of Chicago's 1933 World's Fair. It will house the power and communications exhibits; will be 1,200 by 300 ft., two stories high and of striking modernist design. Steel and special wallboard will form the exterior. White, yellow, red, black and blue will be the dominant colors. The structure will be embellished with hanging gardens and paved terraces

investigate the conduct of a senator. This action has raised the ire of the prime minister and members of the investigating committee, and it is possible that the investigation will be turned over to a Royal Judicial Commission, clothed with authority to force the senator to give evidence. Senator McDougald was charged by Robert Gardiner, leader of the Progressive party in the House of Commons, with having profited hugely through participation in the Beauharnois deal.

Recent evidence given has also revealed that enormous profits were made by various individuals who were linked up with the enterprise from the beginning. Frank P. Jones, one of the promoters of the Beauharnois Syndicate, testified that Walter G. Mitchell, of Montreal, former member of Parliament, profited in the early stages of the syndicate to the same extent as himself, that is, by $785,000 on an initial outlay of $95,000. The evidence of Senator Donat Raymond disclosed that he had profited to the extent of $529,600 by his association with the company, but the senator stoutly denied that he had used his influence with the government to secure the company's charter.

Soviet Turbine-Generator Plants Produce Large Units

STALIN TURBINE PLANT in Leningrad, Russia, will complete its five-year program this month and is expected to double this program by the end of the year. The original plan called for an annual turbine output of 220,000 kw. by the end of the five-year period. This program was increased to 320,000 and later 420,000 kilowatts.

According to the first plan the largest condensation turbine to be produced by 1933 was to be of 10,000 kw. capacity. The plant has already begun the production of a 50,000-kw. turbine and is expected to produce a 75,000-kw. unit in 1932 and a 150,000-kw. machine in 1933. It has also produced a number of small non-condensing turbines and will complete this year two turbines of this type of 12,000 kw. each.

It is reported that the oldest turbine manufacturing firm in England, the Metropolitan Vickers Electrical Company, which is furnishing technical assistance in the Stalin plant, is studying carefully the new methods evolved in this factory with a view to applying them in their own plants.

The first Soviet rotor for a turbine-generator of 24,000 kw. capacity, manufactured at the Electrosila plant in Leningrad, was tested in June and proved satisfactory in every detail. Previously the largest rotors manufactured in the Soviet Union were for generators of not over 12,000 kw. This generator and rotor is consigned for the electric station at Kuznetzk. Work has already been begun on the construction of a 40,000-kw. generator, the largest yet to be undertaken in Russia.

COMING CONVENTIONS

American Society of Mechanical Engineers. Regional meeting in Kansas City, Mo., Sept. 7-9. Annual meeting in New York City, Nov. 30-Dec. 4. Secretary, Calvin W. Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. District meeting at Lake Tahoe, Calif., Aug. 25-28. District meeting at Kansas City, Mo., Oct. 22-24. Secretary, F. L. Hutchinson, 33 West 39th St., New York.

American Welding Society. Fall meeting at the Copley-Plaza Hotel, Boston, Mass., Sept. 21-25. Secretary, M. M. Kelly, 33 West 39th St., New York City.

Association of Edison Illuminating Companies. Forty-seventh annual meeting at The Greenbrier, White Sulphur Springs, W. Va., Sept. 21-25. Secretary, Preston S. Millar, 80th St. and East End Ave., New York City.

International Railway Fuel Association. Annual convention at the Hotel Sherman, Chicago, Ill., Sept. 15-16. Secretary, C. T. Winkless, Room 700, La Salle Street Station, Chicago, Ill.

National Association of Power Engineers. Annual convention and mechanical exposition in the Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago.

Southwest Power Conference and Show will be held in Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, George F. Klein, Chamber of Commerce, Kansas City, Mo.

Third International Conference on Bituminous Coal. At Carnegie Institute of Technology, Pittsburgh, Pa., Nov. 16-21. Chairman, Thomas S. Baker, president of Carnegie Institute of Technology.

Universal Craftsmen Council of Engineers. Annual convention at the Sherman Hotel, Chicago, Ill., Aug. 4-8. Secretary of Convention Committee, James J. Blaine, 7342 Harvard Ave., Chicago, Ill.

William McClave Dies

WORD has just been received that William McClave, one of the founders and president of the McClave-Brooks Company, Scranton, Pa., died on July 1. He was 87 years old.

Born in Scotland on Feb. 7, 1884, Mr. McClave came to this country at the age of two years with his parents. He received his early education in Scranton and worked as a journeyman tinsmith for some years. While in business in Pittston, he invented the Dockash shaking grate for kitchen stoves, which was the first of his many inventions. With R. C. Brooks he founded the McClave-Brooks Company to manufacture his inventions.

Mr. McClave held over 100 domestic patents. Besides the Dockash grate, he invented the first dumping grate for burning small anthracite, as well as the first forced-draft under-grate blower. In later years he developed many other stoker and grate products.

Personals

JAMES A. POWELL, vice-president and assistant chief engineer of W. S. Barstow & Company, the engineering and construction unit of the Associated Gas & Electric system, has been honored with the degree of doctor of science by North Carolina State College. The degree was awarded in recognition of Mr. Powell's outstanding accomplishments in the field of mathematical engineering.

LESTER S. READY, consulting engineer of San Francisco, and formerly chief engineer of the California Railroad Commission, has been employed by the City Council of San Diego, Calif., to investigate a proposition made by Fairbanks, Morse & Company to install a municipal diesel-electric plant for downtown street lighting, which is now being served by the San Diego Consolidated Gas & Electric Company. Mr. Ready has also been instructed to make a general report on the costs of utility service in the city and the possibilities of bringing natural gas there.

THOMAS W. MARTIN, president of the Alabama Power Company and the Commonwealth & Southern Corporation, has been awarded the honorary degree of doctor of laws by Cumberland University.

F. HUGH MOREHEAD, chief engineer of the Walworth Manufacturing Company, Boston, Mass., was elected vice-president in charge of engineering of the company at a recent meeting of the board of directors.

VINCENT E. MCMULLEN, works manager of the Indianapolis plant of Fairbanks, Morse & Company, was elected president of the Indianapolis branch of the National Metal Trades Association at its 25th annual dinner, held recently.

S. T. NELSON, associated with the Sullivan Machinery Company, Michigan City, Ind., for the past 45 years, has resigned as works manager.

EDWARD J. MEHREN, vice-president of the McGraw-Hill Publishing Company, and formerly editor of *Engineering News-Record*, has resigned to assume the presidency of the Portland Cement Association. Mr. Mehren's connection with the McGraw-Hill company and its predecessors extended over a period of 22 years.

FRANK C. RUSHING, of the industrial motor engineering department of the Westinghouse Electric & Manufacturing Company, has received from the company the Lamme Memorial Scholarship Award, which will enable him to continue his engineering studies at the Universities of Charlottenburg and Berlin, Germany, during the year 1931-32. Since joining the Westinghouse organization in 1928, his principal activity has been on steel mill motor design. At the German universities he will specialize in measurement and abatement of noise in machinery.

Business Notes

GENERAL ELECTRIC COMPANY, Schenectady, N. Y., announces that orders received for the first six months of this year amounted to $141,428,978, compared with $190,313,758 for the corresponding period of last year. Sales billed for the six months of 1931 totaled $141,180,091, compared with $197,229,347 for the first six months of 1930. Profit available for dividends on common stock for the first six months was $21,523,723, or 75c. per share, compared with $29,273,276, or $1.01 per share, for the corresponding period last year.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., has appointed T. J. Pace, assistant to vice-president in charge of general market planning and research analysis; M. B. Lambert, sales manager in charge of the transportation department; O. F. Stroman, sales manager in charge of the industrial department; and R. A. Neal, sales manager in charge of the central station department. In announcing the appointments, J. S. Tritle, vice-president and general manager of the company, stated that changed economic conditions required constructive realignment of all departments, so that the company could more effectively serve its thousands of customers and at the same time carry on more progressive development for the needs of all industries.

UNION CHAIN & MANUFACTURING COMPANY, Sandusky, Ohio, announces that E. O. Williams has been placed in charge of the Philadelphia office, located in the Bourse Building. Mr. Williams has been associated with the power transmission field in various sales capacities for the past sixteen years and was formerly manager of the HOWE CHAIN COMPANY.

SPANG, CHALFANT & COMPANY, Pittsburgh, Pa., announces the opening of a sale office in the Russ Building, San Francisco, Calif. J. V. Greer, formerly manager of the company's Birmingham sales office, will be in charge of the new office.

ELLISON DRAFT GAGE COMPANY, Chicago, Ill., announces the appointment of the Hauer Power Equipment Company, Union Trust Building, Cincinnati, Ohio, as exclusive representative in that city and southwestern Ohio territory, and of L. Wharton-Bickley, Bailey Building, Philadelphia, Pa., as representative in eastern Pennsylvania and southern New Jersey.

VIGILANTE PUMP COMPANY has commenced the manufacture of centrifugal pumps for deep well purposes at 6225 East 14th St., Oakland, Calif. The company plans to manufacture deep-well turbine-pumps within the next few months. These products will be marketed under the trade name "Vigilante." Charles E. Mowry is the owner and manager of the company.

How's Business?

INDUSTRIES closest to the consumer are responding strongly to replacement demand at prevailing low prices, according to *The Business Week*, July 29, and the rapid rise in electric power production since early June reflects diversified increase in productive activity. Commodity price levels have shown stability for six weeks. Second quarter earnings reports reflect increasingly successful readjustment of corporate operations to new conditions. The construction, equipment and correlated industries still lag for lack of stimulus of easy investment markets and business initiative; but persistent, large-scale pressure toward lower long-term domestic money costs, through aggressive Federal Reserve open market policies, could correct this situation and speed recovery.

Production of electricity by public utilities for the week ended July 18 was 1,666,848,000 kw.-hr., according to N.E.L.A. figures. This shows an increase over the previous week, but it is 1.6 per cent below the corresponding period of last year.

Trade Catalogs

SMOKE WASHERS — The results achieved by the use of smoke washers in the Sioux City Gas & Electric Company's power plant at Sioux City, Ia., are described and illustrated in a recent publication of the American Smoke & Soot Washer Company, 55 West 42nd St., New York, N. Y.

AIR HEATERS—Construction details, operation and applications of the Type C "Thermix" air heater are covered in an illustrated bulletin recently issued by the Prat-Daniel Corporation, 183 Madison Ave., New York, N. Y.

POWER PLANTS—"A Tax Free Municipality" is the title of an illustrated booklet just issued by the Burns & McDonnell Engineering Company, Interstate Building, Kansas City, Mo., which describes the design, construction and operation of the municipal power plant at Ponca City, Okla.

BELTING—Practical features of the design and maintenance of conveyor and elevator belts are covered in a recent illustrated publication of the Diamond Rubber Company, Akron, Ohio, entitled "Belt Practice." Formulas and tables for the number of plies, horsepower, speed and capacity are given, together with suggestions on the installation and care of belting.

FRICTION MATERIALS—"Controlling the Wheels of Industry" is the title of a recent publication of the Johns-Manville Corporation, 292 Madison Ave., New York, N. Y., which describes and illustrates the use of friction materials in cranes, power shovels, hoists and machine tools.

MOTORS — The Reliance Electric & Engineering Company, 1042 Ivanhoe Road, Cleveland, Ohio, has just issued a new bulletin (No. 209), which describes and illustrates the constructional features of Type T heavy-duty motors for direct current. Many photographs of actual installations are included, together with tables of ratings and engineering specifications.

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Fuel Prices

FUEL OIL

Boston—July 20, tank-car lots, f.o.b. 12@14 deg. Baumé, 2.9c. per gal.; 28@32 deg., 4.83c. per gal.

New York—July 23, f.o.b. Bayonne, N. J., 28@34 deg. Baumé, industrial use, tank-car lots, 4c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 5c. per gal.

Philadelphia—July 22, No. 3, industrial gas oil, $1.83 per bbl.; No. 4, light industrial fuel oil, $1.31 per bbl.; No. 5, medium industrial fuel oil, $1.20 per bbl.; No. 6, heavy (Bunker C), $1.05 per bbl.

Pittsburgh—July 22, f.o.b. local refinery, fuel oil, 30@34 deg., 2.375c.@2.625c. per gal.; 36@40 deg., 2.375c.@2.625c. per gal.

Cincinnati — July 14, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4.5c. per gal.; 26@30 deg., 4.75c. per gal.; 30@32 deg., 5c. per gal.

Chicago—July 14, tank-car lots, f.o.b. Oklahoma; freight to Chicago, 90c. per bbl. or 42 gal.; 18@22 deg., 22.5c. per bbl.; 22@24 deg., 25c. per bbl.; 24@26 deg., 27.5c. per bbl.; 26@28 deg., 32.5 per bbl.; 28@30 deg., 37.5 per bbl.

St. Louis—July 21, tank-car lots, f.o.b. St. Louis, 24@26 deg., 99.5c. per bbl., or 42 gal.; 26@28 deg., $1.045 per bbl.; 28@30 deg., $1.095 per bbl.; 30@32 deg., $1.145 per bbl.; 32@36 deg., gas oil, 2.401c. per gal.; 38@40 deg., distillate, 3.026c. per gal.

Dallas—July 18, f.o.b. local refinery 24@26 deg., 70c. per bbl. or 42 gallons.

COAL

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Pool 9, super low-vol..	New York...	$1.65 @$1.80
Pool 10, h. gr. low-vol.	New York...	1.50 @ 1.65
Pool 11, low-vol.....	New York...	1.40 @ 1.50
Smokeless, mine-run..	Chicago.....	1.50 @ 1.75
Smokeless, slack.....	Chicago.....	.50 @ 1.00
Harlan, Ky., slack....	Chicago.....	.85 @ 1.10
Franklin, Ill., mine-run	Chicago.....	2.15
Franklin, Ill., screen...	Chicago.....	1.10 @ 1.75
Ind. 5th Vein, m.-r....	Chicago.....	1.20 @ 1.75
Standard Ill., mine-run	St. Louis....	1.25 @ 1.40
W. Ky., mine-run	Louisville....	.85 @ 1.10
W. Ky., slack.....	Louisville....	.60 @ .75
Pittsburgh, mine-run.	Pittsburgh....	1.35 @ 1.45
Smokeless, mine-run..	Cincinnati...	1.65 @ 1.75
Smokeless, slack.....	Cincinnati...	.75 @ 1.25
Kanawha, mine-run..	Cincinnati...	1.00 @ 1.35
Kanawha, nut-slack.	Cincinnati...	.40 @ .85
Anthracite (Net Tons)	At Mine, for Shipment to	Price per Ton
Buckwheat.....	New York...	$3.10 @$3.25
Barley.....	New York...	.90 @ 1.40

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ala., Montgomery — Constructing Quartermaster, Maxwell Field, will receive bids until Aug. 11, furnishing and installing boiler plants, outside distribution system, and steam conduit drains at Maxwell Field, here.

Arkansas—Phoenix Utility & Constr. Co., subsidiary of Electric Bond & Share Co., M. Larnard 2 Rector St., New York, in charge, will build hydro electric plant, incl. concrete dam, on White River, near Cotter, by separate contracts. Estimated cost $25,000,000. Preliminary site operations have been started: no contracts awarded.

Calif., Los Angeles—Bd. of Supervisors of Los Angeles Co., Courthouse, will receive bids until Aug. 3, for the construction of 5.42 mi. of vitrified pipe and cast-iron pipe sewers, including pumping plant, in Artesia Ave. and Adams St.

Calif., Pasadena—City has awarded the contract for a steam condenser for the municipal light plant, to Ingersoll-Rand Co. of Calif., 1460 East 4th St., Los Angeles, $59,750.

D. C., Wash.—Potomac Electric Power Co., plans to build an auxiliary power plant in Southwest section. Estimated cost is $5,000,000.

Ill., Chicago—Chicago World's Fair, 1933, 160 North LaSalle St., awarded contract for the construction of an electrical group of buildings to consist of 3 units, radio, communication and power generation, distribution and utilization, to W. E. O'Neil Construction Co., 308 West Washington St. Estimated cost $900,000.

Ill., Chicago—Graham, Anderson, Probst & White, Archts., 80 East Jackson Blvd., awarded contract for the construction of a 45 story, 322 x 189 ft. store and office building at LaSalle, Clark and Adams Sts., for the Marshall Field Estate, to George A. Fuller Co., 140 South Dearborn St. Estimated cost $12,000,000.

Ill., Chicago—South Park Comrs., M. E. Connelly, Secy., 57th St. and Cottage Grove Ave., will receive bids until Aug. 10 for certain work in the completion of the interior of the restoration of the Fine Arts building in Jackson Park. Project will include heating and ventilating work. Graham, Anderson, Probst & White, 80 East Jackson Blvd., are architects.

Ind., Ft. Wayne—Treasury Dept., Office of Supervising Architect, Washington, D. C., will receive bids until Aug. 14, for the construction of a 3 story, 150 x 180 ft. post office, here, including steam heating plant, two electric freight elevators, etc. Estimated cost $550,000. G. Mahurin, Ft. Wayne, is architect. R. W. Noland, Ft. Wayne, is engineer.

Ia., Lake Mills—City will receive bids until Aug. 17, for the construction of a 1 story, 38 x52 ft. light and power plant. Bonds for $90,000 recently voted for project. J. D. Kent, City Clk.

Ia., Lenox—City voted $100,000 bonds for the construction of a power plant.

Me., West Pownal—State School for Feebleminded, P. E. Vosburgh, Supt., is having plans prepared for an addition to be used as a power plant and laundry. Estimated cost $40,000. Coombs & Harriman, 11 Lisbon St., Lewiston, Archts.

Mass., North Wilbraham—Collins Manufacturing Co., 56 Suffolk St., Holyoke, is having plans prepared for a 1 story, brick and concrete power plant. Estimated cost $50,000. McClintock & Craig, 458 Bridge St., Springfield, are architects.

Minn., Moorhead—Commission of Administration and Finance, Capitol, St. Paul, let contract for the construction of a 3 story main recitation and physical education building, 3 story demonstration school and 1 story central heating plant, at the State Teachers College, here, to Bracker Construction Co., 1008 Builders Exchange, Minneapolis. Estimated total cost $765,000.

Neb., Holdredge—City awarded contracts for power plant improvements as follows: surface condenser to Elliott Co., 724 Union State Bank Bldg., Omaha, $6,526; turbo generator and switchboard to General Electric Co., Dwight Bldg., Kansas City, $21,859; feed water regulator to F. W. Hay & Co., Omaha, $124; sump pump to Forslund Pump & Machinery Co., 3031 Main St., Kansas City, $154; superheater to Foster-Wheeler Corp., Bd. of Trade Bldg., Kansas City, $2,550; cooling towers to J. F. Pritchard & Co., Dwight Bldg., Kansas City, $3,055.

N. J., Little Falls—Passaic Valley Water Commission, 156 Ellison St., Paterson, will receive bids until Aug. 12, Contract 12, furnishing and installing electrical work at pumping station, here. Work includes complete substation with three 1,250 kva., single-phase transformers for 26,400/2,400 volt service with spare and subsidiary transformers, busses and accessories; complete switchboard of 24 panels with switches, instruments and wiring, substitution of of 50 small alternating motors for existing direct current motors, cables and ducts for connection of fifteen motors and four generators to the switchboard, transmission line, etc. Frank A. Barbour and Weston E. Fuller, c/o Fuller & Everett, 25 West 43rd St., New York, are engineers.

N. J., Long Branch—E. C. Hazard Hospital, 81 Washington St., retained Charles E. Hartmann, Archt., Greensburgh, N. C., to prepare sketches for the construction of a 10-story hospital, including steam heating system, at Washington Ave. and Dewey St. Estimated cost $1,000,000.

N. J., Secaucus—Board of Freeholders, Court House, Jersey City, is receiving bids until Aug. 13, for the construction of an auxiliary steam line, including pipe line work, etc., between the power house and the Contagious Diseases Hospital at Laurel Hill. Estimated cost $25,000. Frank J. Radigan, Engr.

N. M., Albuquerque—U. S. Veterans Bureau, c/o L. H. Tripp, 764 Arlington Bldg., Wash., D. C., let contract for group of hospital buildings, here, including 30 story main building, to Murch Bros., St. Louis, Mo., $772,000. Contract for two elevators awarded to Kimball Bros., Council Bluffs, Ia., $18,837. Entire project, including equipment for utilities, to cost $1,200,000.

N. Y., Brooklyn—Ice Palace Corp., 393 7th Ave., New York, abandoned plans to construct ice skating pavilion at 588 Flatbush Ave.

N. Y., Buffalo — Adjutant General, State Capitol, Albany, will receive bids until Aug. 13, for heating work, replacement of boilers, and repairs to heating system at 174th Infantry Armory, here.

N. Y., Geneseo—Comr. of Education, Education Bld., Albany, will receive bids until Aug. 18, for construction and heating work for additional boiler and service connections at State Normal School, here.

N. Y., Oswego—Commissioner of Education, Education Bldg., Albany, N. Y., will receive bids until Aug. 6, installing heating work, new boilers, etc., at State Normal School, here.

N. C., Oteen—Veterans Administration, Construction Service, Room 764 Arlington Bldg., Wash., D. C., will receive bids until Aug. 11, for boiler house, concrete chimney, etc., at U. S. Veterans Hospital, here.

S. D., Aberdeen—State is having revised plans prepared for the construction of a boiler and engine house at the Northern State Normal and Industrial School. J. Berg, Pierre, is state engineer. G. F. Fossum, Aberdeen, is architect. Contracts for equipment have been awarded.

S. D., Brookings—State College, C. W. Pugsley, Pres., awarded contract for constructing an addition to the present power plant, furnishing and installing one 450 hp. boiler, etc., to R. A. Mark, Brookings.

S. D., Vermilion—City awarded contracts for constructing municipal light and power plant as follows: general to Henry Carlson Co., 407 Minnehaha Bldg., St. Falls, $31,000; engines to Fairbanks-Morse Co., 417 South 4th St., Minneapolis, Minn., $50,625; two 525 hp. switchboards to Commonwealth Electric Co., 417 Bway., St. Paul, Minn., $13,000.

Tenn., Memphis—Bd. of Water Commissioners will receive bids until Aug. 12, for the construction of James Sheahan Water Pumping Station at Normal State Teachers College, including centrifugal pumping units, two 625 kva. turbo generating units, two 500 hp. boilers, etc. Estimated cost $2,000,000. Fuller & McClintock, 170 Bway., New York, are engineers. T. H. Allen, 65 McCall St., Memphis, is associate engineer.

Va., Langley Field—U. S. Army Air Corps, Constructing Quartermaster, Fort Monroe, awarded contract for the construction of eleven air corps hangars, annexes, connecting bays and power house, here, to M. H. Serbel, Inc., Detroit, Mich. Estimated cost $498,000.

Equipment Wanted

Air Compressor—Oakland, Calif.—East Bay Municipal Utility Dist., 512 16th St., Oakland, is receiving bids until Aug. 4, furnishing one 3-cylinder portable air compressor, direct connected to 4-cylinder heavy duty gasoline engine. J. H. Kimball is secretary.

Pumping and Filter Equipment—Peru, Ind.—City, H. E. Worl, Clk., will receive bids until Aug. 4, furnishing pumping and filter equipment for municipal water plant. Estimated cost $25,000.

Pumping Engine—Lynn, Mass.—City is receiving bids for furnishing triple combination pumping engine, speed 1,000 g.p.m.

N. H., Portsmouth—Bureau Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 5, for 750 kw. turbo-generator.

Generators and Electric Service Connections—Oxford, N. Y.—Superintendent of Standards and Purchase, State Capitol, Albany, will receive bids until Aug. 13, installing generators and electric service connections at New York State Women's Relief Corps Home, here.

Refrigeration Equipment—Cleveland, O.—City will receive bids until July 31, refrigeration equipment for Division of Light & Heat. L. A. Quayle, City Hall, is engineer.

Industrial Projects

Colo., Salida—Travertine Co., c/o J. H. Haynes, Salida, and John A. Taft, 162 North Franklin St., Chicago, Ill., plans to construct a travertine mill here. Estimated cost $1,000,000.

Md., Baltimore—Arundel-Brooks Concrete Co., Pier 2, Pratt St., plans to construct a plant at Wolfe and Fell Sts., for the manufacture of premixed concrete. Owner builds. Estimated cost $50,000. Private plans. Conveyor, etc., will be purchased.

Mass., Boston—Royal Curtain Manufacturing Co., 35 Kingston St., has awarded the contract for the construction of a factory on Hyde Park Ave., Hyde Park, to M. Slotnick, 333 Washington St. Estimated cost $40,000.

Mich., Detroit — Chrysler Corp., 341 Massachusetts Ave., Highland Park, plans the construction of a 1 story, 192 x 240 ft. auto factory on Mt. Elliott Ave. and Lynch Rd. Estimated cost $140,000.

Nev., Reno—Parker Brick Co., recently organized, H. E. Roberts, Reno, Vice-Pres., plans the construction of a plant for the manufacture of brick, clay and tile. Estimated cost $40,000.

N. J., Bloomfield—General Electric Co., Lawrence St., is receiving bids for the construction of a 1 story addition to its factory here.

N. Y., Brooklyn—Hilo Varnish Co., March and Flushing Aves., has awarded the contract for the construction of a group of factory buildings at Stewart Ave. and Harrison Pl., to the Turner Construction Co., Graybar Bldg., New York. Project includes 3 story and basement reinforced concrete building and three 1 story structural steel buildings for storage, varnish cooking and thinning.

N. Y., Buffalo—A. F. Oliver Gear & Machine Co., 60 Cherry St., has awarded the contract for the construction of a 1 story, 85 x 250 ft. addition to its plant to the Hydro Construction Co., Stock Exchange Bldg. Estimated cost $39,000.

Tex., Longview—Danciger Oil & Refinery Co., Fort Worth and Longview, is receiving bids for the construction of a 10,000 bbl. oil and gas refinery plant in Gregg County between Longview and Kilgore. Company will also build a network of gathering lines in Gregg County and surrounding territory to supply oil to the plant.